Canada's National Forest Inventory
Ground Sampling Guidelines

October 2008

Version 5.0

Library and Archives Canada Cataloguing in Publication

Canada's National Forest Inventory ground sampling guidelines : specifications for ongoing measurement.

Available also on the Internet.
Includes bibliographical references.
ISBN 978-1-100-11329-6
Cat. no.: Fo144-6/2008E

1. Forest surveys--Canada--Methodology--Handbooks, manuals, etc. 2. Vegetation surveys--Canada--Methodology--Handbooks, manuals, etc. 3. Environmental sampling--Canada--Handbooks, manuals, etc. 4. Aerial photography in forestry--Canada--Handbooks, manuals, etc. 5. Forests and forestry--Canada--Measurement. I. Canadian Council of Forest Ministers

SD387 S86 C36 2008 333.75072'3 C2008-980390-6

Library and Archives Canada Cataloguing in Publication

Canada's National Forest Inventory ground sampling guidelines [electronic resource] : specifications for ongoing measurement.

Electronic monograph in PDF format.
Issued also in printed form.
Includes bibliographical references.
ISBN 978-1-100-11330-2
Cat. no.: Fo144-6/2008E-PDF

1. Forest surveys--Canada--Methodology--Handbooks, manuals, etc. 2. Vegetation surveys--Canada--Methodology--Handbooks, manuals, etc. 3. Environmental sampling--Canada--Handbooks, manuals, etc. 4. Aerial photography in forestry--Canada--Handbooks, manuals, etc. 5. Forests and forestry--Canada--Measurement. I. Canadian Council of Forest Ministers

SD387 S86 C36 2008 333.75072'3 C2008-980391-4

ACKNOWLEDGEMENTS

These National Forest Inventory Ground Sampling Guidelines were developed by the Canadian Forest Inventory Committee (now the NFI Task Force under the Canadian Council of Forest Ministers). The Climate Change Action Fund and the National Forest Inventory (NFI) funded the initial version of the project.

So many people made substantial input into the development of these guidelines that it would be impossible to mention all of their names. Major contributions of thoughts, ideas, and concepts came from M. Gillis, R. Wiart, G. Russo, T. Brierley, V. Sundstrom M. Jones, J.A. Trofymow, W. Kurz, C. Shaw, A. Harris, T. Varem-Sanders, A. Inselberg, J. Parton, S. Dagnault, L. Bowdige, P. Bernier, J. Bhatti, K. Keys, C. Preston, and all of the members of the NFI Task Force. The various individuals who reviewed draft materials and shared insight and knowledge based on field experience, at all stages of this document's preparation, are also acknowledged.

ABSTRACT

The Canadian Forest Service has worked with the provinces and territories to develop a new approach for the National Forest Inventory (NFI). This new approach is a response to changes in data and information needs. For example, data to evaluate criteria and indicators of sustainable development are required, as well as data on changes in the resources and data on non-timber resources.

The basic NFI sampling design includes the selection of sample units using a 20 × 20 km grid network; photo plot attribute estimation from air photos; and the selection of a subset (1 in 10) of these photo plots for ground sampling. These guidelines describe the configuration and major components of the ground plot design.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS II

ABSTRACT III

LIST OF FIGURES VIII

LIST OF TABLES X

1.0 INTRODUCTION 1

2.0 BACKGROUND 3

3.0 NFI GROUND PLOT DESIGN 5

3.1 PLOT DESIGN CRITERIA 5
3.2 RECOMMENDED PLOT DESIGN 8
3.3 FIELD PROCEDURES AND PLOT CARDS 9

4.0 FIELD ORIENTATION AND NAVIGATION 11

4.1 INTRODUCTION 11
4.2 OBJECTIVES 11
4.3 GENERAL PROCEDURES 11
4.4 DETAILED PROCEDURES 12
4.5 ONGOING MEASUREMENT PROCEDURES 20

5.0 PLOT ESTABLISHMENT AND SEQUENCE OF MEASUREMENTS 23

5.1 INTRODUCTION 23
5.2 OBJECTIVES 23
5.3 DEFINITIONS 23
5.4 GENERAL PROCEDURES 24
5.5 DETAILED PROCEDURES 27
5.6 ONGOING MEASUREMENT PROCEDURES 33

6.0 GROUND PLOT PHOTOGRAPHS 39

6.1 INTRODUCTION 39
6.2 OBJECTIVES 39
6.3 GENERAL PROCEDURES 39
6.4 DETAILED PROCEDURES 39
6.5 GROUND PLOT PHOTO RELEASE FORM 43
6.6 ONGOING GROUND PLOT PHOTOGRAPHS 43

7.0 WOODY DEBRIS MEASUREMENTS 45

7.1 INTRODUCTION 45
7.2 OBJECTIVES 45
7.3 DEFINITIONS 45
7.4 GENERAL PROCEDURES 45
7.5 DETAILED PROCEDURES 46

7.6 Ongoing Measurement of Woody Debris 57

8.0 Surface Substrate Measurements 59

8.1 Introduction 59
8.2 Objectives 59
8.3 Definitions 59
8.4 General Procedures 59
8.5 Detailed Procedures 60
8.6 Ongoing Measurement Procedures for Surface Substrate 64

9.0 Ecological Plot 67

9.1 Introduction 67
9.2 Objectives 67
9.3 Definitions 67
9.4 General Procedures 68
9.5 Detailed Procedures 68
9.6 Ongoing Measurement Procedures of the Ecological Plot 77

10.0 Soil Attributes 79

10.1 Introduction 79
10.2 Objectives 79
10.3 Definitions 79
10.4 General Procedures 80
10.5 Detailed Procedures 80
10.6 Ongoing Measurement Procedures for Soil Pit 89

11.0 Microplots 91

11.1 Introduction 91
11.2 Objectives 91
11.3 Definitions 91
11.4 General Procedures 92
11.5 Detailed Procedures 93
11.6 Ongoing Measurement for Microplots 112

12.0 Large Tree Plot 115

12.1 Introduction 115
12.2 Objectives 115
12.3 Definitions 115
12.4 General Procedures 116
12.5 Detailed Procedures 117
12.6 Ongoing Measurement Procedures for the Large Tree Plot 132

13.0 Small Tree, Shrub, and Stump Plot 135

13.1 Introduction 135
13.2 Objectives 135
13.3 Definitions 135
13.4 General Procedures 135
13.5 Detailed Procedures 136
13.6 Ongoing Measurement of the Small Tree, Shrub, and Stump Plot 143

14.0 Site Assessment 145

14.1 Introduction 145
14.2 Objectives 145
14.3 General Procedures 145
14.4 Detailed Procedures 146
14.5 Ongoing Measurement for Site Assessment 157

15.0 References 159

LIST OF APPENDICES

APPENDIX A:	GLOSSARY OF TERMS	A1
APPENDIX B:	EXAMPLES OF COMPLETED FIELD CARDS	A11
APPENDIX C:	HIDDEN PLOT PROCEDURES	A34
APPENDIX D:	HANDLING UNAVAILABLE, DIFFICULT ACCESS, AND PARTIAL GROUND PLOT SITES	A37
APPENDIX E:	NFI TREE SPECIES LIST (VERSION 4.1, SEPTEMBER 2007)	A47
APPENDIX F:	EQUIPMENT LIST	A57
APPENDIX G:	PHOTO RELEASE FORM	A62
APPENDIX H:	RANDOMIZED NUMBERS	A63
APPENDIX I:	CALCULATING SLOPE ALLOWANCES	A65
APPENDIX J:	MEASURING DIAMETERS	A66
APPENDIX K:	CALCULATION OF BASAL AREA	A68
APPENDIX L:	CORE SAMPLING	A70
APPENDIX M:	SOIL SAMPLE PROCESSING LAB ANALYSIS PROTOCOL	A77
APPENDIX N:	PHOTOS OF FIELD SAMPLING TOOLS USED IN FOREST FLOOR AND SOIL SAMPLE EXCAVATION	A81
APPENDIX O:	NFI SOIL SAMPLE AND SHIPPING LABELS	A83
APPENDIX P:	NFI LAND COVER CLASSIFICATION SCHEME	A85

LIST OF FIGURES

FIGURE 3.1 RECOMMENDED NFI GROUND PLOT DESIGN. 9

FIGURE 5.1 NFI GROUND PLOTS. 26

FIGURE 5.2 NFI WOODY DEBRIS AND SURFACE SUBSTRATE TRANSECTS. 28

FIGURE 5.3 NFI ECOLOGICAL PLOTS. 29

FIGURE 5.4 NFI MICROPLOTS. 30

FIGURE 5.5 NFI LARGE TREE PLOT. 31

FIGURE 5.6 LAYOUT OF LARGE TREE PLOT. 32

FIGURE 5.7 NFI SMALL TREE, SHRUB, AND STUMP PLOT. 32

FIGURE 5.8 NFI SITE INFORMATION PLOT(S). 33

FIGURE 5.9 FIRST ONGOING MEASUREMENT STATION SETUP FOR SURFACE SUBSTRATE MEASUREMENTS. 34

FIGURE 5.10 LOCATIONS OF THE ONGOING MEASUREMENT MICROPLOTS. 36

FIGURE 6.1 EXAMPLE OF GROUND PLOT CENTER PHOTO (PHOTO 1). 41

FIGURE 6.2 EXAMPLE OF TRANSECT PHOTO (PHOTOS 2–5). 41

FIGURE 6.3 EXAMPLE OF REPRESENTATIVE PHOTO (PHOTO 6). 42

FIGURE 6.4 EXAMPLE OF OVERHEAD PHOTO (PHOTO 7). 42

FIGURE 6.5 EXAMPLE OF SOIL PIT PHOTO (PHOTO 8). 43

FIGURE 7.1 TRANSECT LAYOUT AND INCREMENT MARKING ALONG TRANSECT. 47

FIGURE 7.2 MEASURE WOODY DEBRIS WHERE THE TRANSECT CROSSES THE CENTERLINE OF THE PIECE. 49

FIGURE 7.3 MEASURE WOODY DEBRIS AT EACH TRANSECT CROSSING. 49

FIGURE 7.4 SIDE VIEW OF PARTIALLY BURIED CWD. 50

FIGURE 7.5 EXAMPLE OF A GO-NO-GO GAUGE USED TO DETERMINE DIAMETER CLASS OF SMALL WOODY DEBRIS ALONG THE LINE TRANSECT. 54

FIGURE 8.1 STATION SETUP FOR SURFACE SUBSTRATE MEASUREMENTS (SAMPLE EVERY OTHER STATION AT DEEP ORGANIC SITES). 61

FIGURE 8.2 FIRST ONGOING MEASUREMENT STATION SETUP FOR SURFACE SUBSTRATE MEASUREMENTS (SAMPLE EVERY OTHER STATION AT DEEP ORGANIC SITES). 65

FIGURE 8.3 SECOND ONGOING MEASUREMENT STATION SETUP FOR SURFACE SUBSTRATE (SAMPLE EVERY OTHER STATION AT DEEP ORGANIC SITES). 65

FIGURE 9.1 ECOLOGICAL PLOTS USED FOR IDENTIFYING VEGETATION AND ESTIMATING COVER. 68

FIGURE 9.2 NFI TREE AND SHRUB LAYERS WITH VERTICAL PROJECTION OF CROWN COVERAGES (BCMOF 2007) 69

FIGURE 9.3 EXAMPLE OF UNKNOWN VEGETATION SAMPLE LABEL 72

FIGURE 11.1 FOUR MICROPLOTS (1 M^2) POSITIONED AT THE ENDS OF THE LINE TRANSECTS. 94

FIGURE 11.2 BULK DENSITY SAMPLE EXCAVATION FOR MINERAL SOILS. 101

FIGURE 11.3 PHOTOGRAPH OF SOIL MINERAL SAMPLE EXCAVATION 35–55 CM. PHOTO COURTESY OF LEIGH BLACK. 104

FIGURE 11.4 PHOTOGRAPH OF ORGANIC SOIL SAMPLE EXCAVATION 35–55 CM. PHOTO COURTESY OF MICHELE JONES. 106

FIGURE 11.5 LOCATION OF MICROPLOTS FOR ONGOING MEASUREMENT 112

FIGURE 12.1 LAYOUT FOR LARGE TREE PLOT. 117

FIGURE 13.1 MEASURING LIVE STUMPS 141

FIGURE 13.2 LENGTH MEASUREMENTS OF BROKEN STUMPS 141

LIST OF TABLES

TABLE 3.1 NATIONAL FOREST INVENTORY KEY ATTRIBUTES. 7

TABLE 5.1 SUMMARY OF DATA COLLECTED AT THE PLOT CENTER AND THE SAMPLING METHOD EMPLOYED. 23

TABLE 7.1 WOODY DEBRIS AND STUMP DECAY CLASS DESCRIPTIONS FOR NFI REPORTING. 55

TABLE 8.1 SURFACE SUBSTRATE TYPES AND DEFINITIONS. 63

TABLE 9.1 VEGETATION LAYER CODES FOR THE TREE AND TALL SHRUB ECOLOGICAL PLOT. 73

TABLE 9.2 CONVERSION FACTORS FROM PERCENT COVERAGE TO HORIZONTAL AREA FOR A 10-M RADIUS PLOT. 75

TABLE 9.3 VEGETATION LAYER CODES FOR LOW SHRUB, HERB, BRYOID, AND TREE SEEDLING ECOLOGICAL PLOT. 76

TABLE 9.4 CONVERSION FACTORS FROM PERCENT COVERAGE TO HORIZONTAL AREA FOR A 5.64-M RADIUS PLOT. 76

TABLE 10.1 PIT NUMBER CODES. 81

TABLE 10.2 SOIL MOISTURE CLASS CODES. 82

TABLE 10.3 SOIL DRAINAGE CLASS CODES. 83

TABLE 10.4 CODES FOR SOIL PARENT MATERIAL MODE OF DEPOSITION. 84

TABLE 10.5 HUMUS FORM CODES. 85

TABLE 10.6 EXAMPLES OF ORGANIC SOIL HORIZON DESCRIPTIONS. 86

TABLE 10.7 EXAMPLES OF MINERAL SOIL HORIZON DESCRIPTIONS. 86

TABLE 10.8 EXAMPLE OF RECORDING HORIZONS ATTRIBUTES IN MINERAL SOILS. 87

TABLE 10.9 EXAMPLE OF RECORDING HORIZONS ATTRIBUTES IN ORGANIC SOILS. 87

TABLE 10.10 SOIL COLOR CODES. 88

TABLE 10.11 SOIL TEXTURE CODES. 88

TABLE 10.12 SOIL FEATURES CODES. 89

TABLE 11.1 PIT NUMBER CODES. 109

TABLE 12.1 CROWN CLASS CODES. 122

TABLE 13.1 SMALL TREE STATUS CODES. 138

TABLE 13.2 WOODY DEBRIS AND STUMP DECAY CLASS DESCRIPTIONS FOR NFI REPORTING. 143

TABLE 14.1 PROVINCE AND TERRITORY CODES FOR NFI REPORTING 147

TABLE 14.2 TERRESTRIAL ECOZONE CODES FOR NFI REPORTING 148

TABLE 14.3 LAND COVER CONDENSED VERSION..... 150
TABLE 14.4 SUCCESSIONAL STAGE CODES (DUNSTER AND DUNSTER 1996). 151
TABLE 14.5 WETLAND CLASS CODES. 152

1.0 Introduction

The guidelines described herein meet the basic field sampling requirements for the ground sampling components of the National Forest Inventory (NFI). The attributes to be measured, guidelines for obtaining those measurements, and specifications for ongoing measurement are explained in detail in this document.

These guidelines can be referenced as they exist or modified to meet the objectives of a regional inventory program. Regardless, each province or territory is responsible for acquiring inventory data that meet the standard described in *Canada's National Forest Inventory National Standards for Ground Plots – Data Dictionary* (available on the NFI website <https://nfi.nfis.org>). Each province or territory is responsible for its own quality assurance and field checking program to ensure that consistent, quality data are generated. Change management will be implemented, where required, primarily to the *Data Dictionary*. This document may be updated periodically to reflect those changes.

Several NFI ground plot attributes listed in the *Data Dictionary* will need to be compiled in the office or measured in the lab following the field measurements. This document does not attempt to describe any procedures for compiling or measuring these attributes.

2.0 Background

The objective of the NFI is to assess and monitor the sustainable development of Canada's forests in a timely and accurate manner. The intent is to collect and report information to a set of uniform standards to establish a baseline of where the forest resources are and how they are changing over time. This information will be used to support decisions on policy, trade, and science initiatives, and to respond to regional, national, and international inquiries.

In addition to information collected from photo plots, the design called for the initial establishment of a minimum of 50 forested ground plots per terrestrial ecozone (although no sampling was planned for the Arctic ecozones). For some areas, more intensive sampling was required to meet regional objectives. Attributes and data collected from ground plots complement and enhance the attributes and data from the photo plots. Attributes measured on the ground include a list of all species of plants occurring in a plot, mortality due to stresses (fire, insects, diseases), total aboveground biomass, and mass of all woody debris. The ground plots also contain information that is not normally collected in forest inventories, such as forest floor organics and soil carbon.

Approximately 10% of the photo plot locations (which are on a 20 × 20 km grid across Canada) were selected at random for ground plot sampling. The ground plots are, in most cases, located at the center point of the photo plot. Whenever the randomly selected location fell on a permanently non-treed area, a substitute sample location was chosen, again at random. The non-treed locations maintain their status as NFI ground plots and, although no measurements are taken, the locations are retained in the analysis. Measurements of ground plots are synchronized as much as possible with the interpretation of photo plots.

All NFI plots are permanent. Change to Canada's forests will be estimated from repeated sampling of photo and ground plots. The intent is to collect baseline data by completely sampling the country over 5 years. The first ongoing measurement, starting in 2007, will be spread over a 10-year period. Each successive measurement will be spread over subsequent 10-year periods. The NFI is a joint effort of federal, provincial, and territorial governments and is administered through a memorandum of understanding between the federal government and each jurisdiction.

3.0 NFI Ground Plot Design

This document outlines a set of procedures that provide a consistent format for installing the ground plots to a required standard. Using these guidelines will ensure a known reference for the provinces and territories installing NFI ground sample plots. These guidelines have been adapted from existing provincial programs. A complete description of the ground plot attributes and the ground plot database structure is listed in the *Canada's National Forest Inventory National Standard for Ground Plots Data Dictionary* (available on the NFI website <https://nfi.nfis.org >).

3.1 Plot Design Criteria

The NFI ground sampling design was developed to meet five criteria:

1. Plot compatibility with the inventory design.
2. Appropriate plot type, plot size, and plot shape for the attributes being measured.
3. Design flexibility that is capable of expansion.
4. Design simplicity and effectiveness.
5. Generation of ground plot data that complements NFI photo plot data.

For each criterion, a series of choices are available and the one most adaptable to a given inventory program is chosen. To assist in decision making, comparisons have been made with existing inventories.

Plot Compatibility with Current Inventory Design

While the NFI photo plots were designed to obtain area-based estimates, the NFI ground plots are intended to obtain point-estimate samples. Hence, there is no need to consider polygon-wide estimates. A single sample element is adequate, where a cluster would be inappropriate.

Appropriateness of Plot Type, Size, and Shape

Plot type is important for growth and change measurements. Of the two primary plot types, fixed-area versus variable-radius plots, fixed-area plots are a better design for monitoring growth and change. Fixed-area plots were selected as most appropriate for the NFI. It is easier to assess the changes that have occurred and to identify and measure the same units (e.g., trees) in a fixed-area plot. This is particularly relevant for mortality and harvested trees. Areas converted to non-forest use can also be tracked using ongoing measurements. Many of the remaining attributes, such as the number of forest-dependent species, become more significant in ongoing measurements of change over time than in one-time measurements.

Plot size is a critical factor. If the plot is too large, time is wasted measuring too many trees or other attributes. The extra time spent measuring is not offset by a comparable increase in efficiency. If the plot is too small, not enough information is gathered to reach the optimum point of cost-effectiveness. This point can only be approximated (by varying

plot size) because the number of units (trees) varies from one plot to the next, and several attributes are measured in each plot. The NFI plots are permanent plots, which will be measured over a long period of time and forest conditions could vary greatly over the time frame. A plot size has been selected for each attribute and will be maintained throughout the sampling time frame. This may result in some inefficiency at periods of the forest's development, but in the longer run is expected to be the most efficient process. The plot sizes are not changed over time; therefore, the same area is always being sampled, which greatly simplifies data analysis.

Plot shape is critical in certain instances. For example, a long, narrow plot may be used to counter-act periodicity in the population. However, it is usually a question of simplicity and effectiveness. The recommended plot shape for NFI plots is round; however, the individual provinces and territories can determine the most appropriate shape. Ground plot attributes are measured in five components:

1. **Site assessments:** These do not require a plot with specific boundaries, only an appropriately sized reference area. A circular plot shape would work well since its boundaries can easily be estimated and round plots have less edge (hence less opportunity for edge trees).

2. **Woody debris measurements:** A line intersect sampling method is most commonly used in forest fuel studies to measure these attributes.

3. **Soils attribute measurements:** These are best obtained from a soil pit of an appropriate size.

4. **Tree, shrub, herb, and bryoid measurements:** These plot-based measurements include species, diameter, and heights for the trees, and species and some measurement of size for the shrubs. It includes a species list and cover estimation for all vegetation species. Many different sizes, shapes, and types of plots will work satisfactorily. Again, plot size is more important than shape and type.

5. **Growth and change measurements:** An example of this is volume growth estimation. Plots are required for growth and change measurements. Plot type is more important than plot shape or size in these measurements.

Designating a plot for ongoing measurement affects plot type, size, shape, and plot establishment procedures, since the plot must be relocatable and remeasurable.

Design Flexibility That Is Capable of Expansion

The NFI Design Document lists a set of 25 key attributes designed to satisfy national reporting requirements for criteria and indicators of sustainable forest management (Table 3.1). It is likely that attributes will be added to meet provincial or territorial management requirements. These might include provincial inventory needs, forest health indicators, ecological classification, wildlife, or new national reporting requirements. The design must be sufficiently flexible to accommodate such expansion.

Table 3.1 National Forest Inventory key attributes.

NFI key attributes	
1.	Total forest area
2.	Area by forest type
3.	Area of forest type by age class
4.	Area of forest types by protection status
5.	Area of other wooded land by protection status and type
6.	Area of age classes by protection status
7.	Area and percent of forest land managed primarily for protective functions
8.	Regeneration and afforestation area by type
9.	Area of surface water in forests
10.	Area of forests undisturbed by man
11.	Area of other wooded land undisturbed by man
12.	Number of forest-dependent species
13.	Number of native and exotic species in forests
14.	Origin of seedlings in regenerating areas
15.	Area available for timber production
16.	Area converted to non-forest use
17.	Area and severity of insect attack
18.	Area and severity of disease infestation
19.	Area and severity of fire damage
20.	Area of forest disturbance
21.	Area and percent of forest land with significant soil erosion
22.	Total biomass by forest type, age, succession stage
23.	Total volume of all species on timber producing land
24.	Area/volume of plantations (native/exotic)
25.	Current volume growth (annual) of forest (gross, net)

Design Simplicity and Effectiveness

A simple design facilitates understanding and implementation, and helps to reduce errors. Among the fixed-area plots, the circular type is simple, easy to lay out, and contains the largest area for a given perimeter. This minimizes boundary measurement problems. In dense stands, however, it may be easier to lay out a square versus a circular plot. Once selected, the plot type will need to be maintained for all successive measurements.

An effective design minimizes the cost of obtaining the data. The time required for plot layout and measurements directly affects costs. A suitable target is for a crew to complete simple samples in one day and complex samples in two days. The inventory planner can vary transportation means, crew size, and crew experience to help meet the timing targets.

Ground Plot Data That Complements NFI Photo Plot Data

The ground plot data may be used with the photo plot data for ground truthing, to help develop interpretation keys, or to provide another estimate of the same attribute. This is perhaps the least important plot design criterion and any design modifications to accommodate it will be minimal.

3.2 Recommended Plot Design

The recommended plot design is termed a core plot design because it is likely to be modified by the provinces or territories. As with the overall NFI design, the intent is to have results that meet a common standard, not to have identical methods of achieving those results. Modifications are likely to focus on the size of the plots (e.g., a province or territory may find it more effective, given their individual inventory programs, to make the tree plots larger to meet other needs).

Plot design criteria are met using the core plot design illustrated in Figure 3.1. It is comprised of four concentric, circular plots with two line transects, perpendicular to each other, running through the plot center. Core plot design components include:

1. **Two 30.0 m long, line transects** for measuring woody debris and surface substrate.
2. **Four microplots**, each with a radius of 0.56 m and an area of 1 m^2 (0.0001 ha), for measuring the biomass of small trees and shrubs (< 1.3 m in height), herbs, bryophytes, lichens, fine woody debris, and very small stumps (< 4.0 cm top diameter inside bark). In addition, forest floor and soil bulk density samples are collected from the microplots.
3. **A soil pit** dug outside of the Large Tree Plot, representative of the site, for measuring soil attributes.
4. **Two Ecological Plots** with a radius of 10.0 m (area of 0.0314 ha) and 5.64 m (area of 0.01 ha), for recording a list of all ecological species (and percent cover).
5. **A Large Tree Plot,** with a radius of 11.28 m and an area of 400 m^2 (0.04 ha), for measuring attributes of large trees (trees with dbh ≥ 9.0 cm).
6. **A Small Tree Plot** with a radius of 3.99 m and area of 50 m^2 (0.005 ha), for measuring small trees (trees ≥ 1.3 m in height with a dbh < 9.0 cm), shrubs (≥ 1.3 m in height), and stumps (< 1.3 m in height).

As an option, square plots may be used instead of circular ones. This design satisfies the five aforementioned components:

1. A single sample element satisfies the first criterion: the plot is compatible with the inventory design.
2. Different plot sizes accommodate the measurement of a few large units and many small units, and a fixed-area plot design allows for the monitoring of growth and change. This satisfies the second criterion: the plot design is appropriate for the attributes being measured.
3. The design is flexible and allows for expansion.

4. Circular or square plots, centered on the network grid point, are simple and effective.

5. The design permits the ground plot data to be used with the photo plot data.

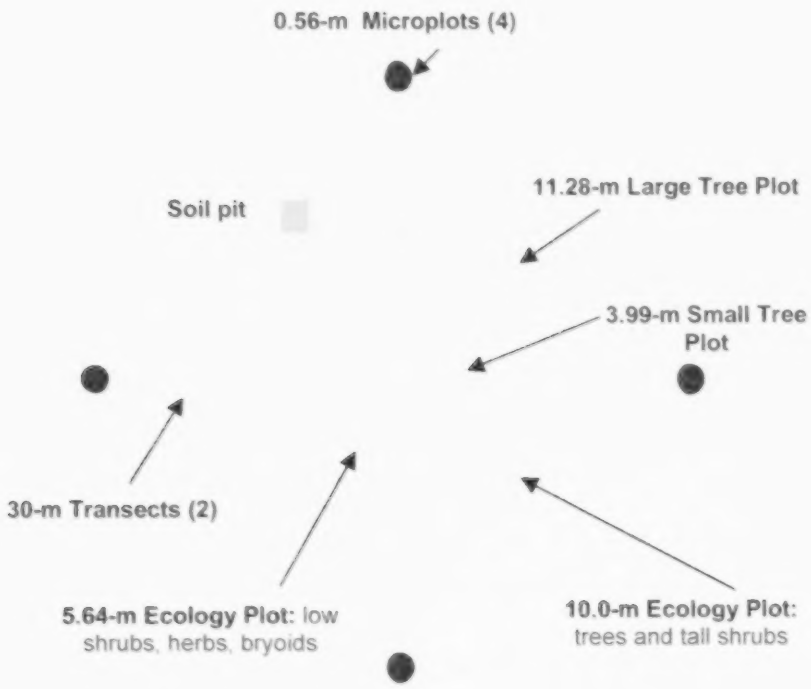

0.56-m Microplots (4)
Soil pit
11.28-m Large Tree Plot
3.99-m Small Tree Plot
30-m Transects (2)
5.64-m Ecology Plot: low shrubs, herbs, bryoids
10.0-m Ecology Plot: trees and tall shrubs

Figure 3.1 Recommended NFI ground plot design.

3.3 Field Procedures and Plot Cards

Standardized field procedures have been developed in cooperation with the provinces and territories. The sampling procedures and associated field cards have been in use in various formats since the initial establishment of the ground samples.

The sampling program has now entered the "ongoing" measurement phase where the initial samples are being revisited for the first time. Attributes collected during the establishment phase have been substantially reviewed by the NFI project office and members of the NFI Task Force. Some measurement procedures were revised and several new attributes are now included in the procedures document to meet defined objectives. The field cards have also been extensively revised to collect the additional data as required.

4.0 Field Orientation and Navigation

4.1 Introduction

This section outlines the steps required for traversing from a geographically located feature (tie-point) to plot center. It is important to follow standard procedures for locating, marking, and recording plot centers as the plots must be relocatable for quality control and ongoing measurement. Traditional survey methods should be employed as the primary method of locating the plot center, with a global positioning system (GPS) to assist in confirming the location.

4.2 Objectives

- To establish sample plots for the National Forest Inventory at pre-determined locations.
- To establish these sample points at an unbiased location.
- To enable relocation of the samples for ongoing measurements.

4.3 General Procedures

The field crew is responsible for selecting suitable tie-points, navigating to the reference point, locating plot center, and recording the information. The route must be suitably marked to locate the ground plot center, and to aid in short- and long-term sample relocation for check plots and ongoing measurements. This section describes the procedures used to:

1. locate the ground plot center that corresponds with the correct UTM coordinates for the sample;
2. mark and document the location and navigation points to allow for short- and long-term sample relocation; and
3. facilitate no special treatment of the plots; the plot marking and tree marking will be hidden as much as is practical.

Note: GPS should only be used up to the location of the reference point. There is still error in GPS readings, especially in dense timber and on steep slopes. The crew will need to confirm that the sample is in the correct location. GPS data will be recorded at the access point (if required), the tie-point, and the plot center. Provincial or territorial programs will provide local procedures for GPS data collection.

Field Cards for Field Orientation and Navigation

Header Information (1a and 1b) (Appendix B, Diagrams 1 and 2)
Plot Header Field card: network label, crew names, sample date, sample tag number, notes, access notes, and map.

Compass Information (2a and 2b) (Appendix B, Diagram 3)

Field card for navigation to plot center: map and photo number, tie-point tree details, 15-m reference point tree details, distance and bearing to plot center, navigation notes, GPS data.

4.4 Detailed Procedures

Office Preparation

Before field visitation, office preparation is required to familiarize the crew with the location of plot center, forest characteristics of the area, and access routes. The following tasks can be completed in the office before field navigation:

1. Identify the location of the plot center on medium-scale aerial photographs.
2. Determine the relative accuracy of the map to photo relationship.
3. View the photo in stereo to observe plot center location and look for potential tie-point locations.
4. Locate a potential tie-point and alternatives on the map and photograph. A tie-point is selected and marked to ensure it can be found again with reasonable effort using the field crew's documentation. A tie-point should:

    - be locatable on the ground
    - be locatable on the appropriate medium-scale aerial photo
    - be locatable on the appropriate inventory map
    - permit efficient access to the sample for short- and long-term sample relocation.

    Possible tie-point locations include:

    - major road junctions (use the intersection of the road centerlines)
    - pre-located, corrected GPS coordinates
    - bridge on a stream crossing (on small creeks, use the centerline of the bridge at the middle of the creek; on larger streams, specify which edge of the stream was used)
    - definite timber boundary features on the photo (cutblock edges should be used with caution as there may have been additional harvesting, or the map placement may be inaccurate)
    - major creek junctions
    - well-defined swamps, ponds, or lake edges.
5. Determine the most appropriate access route and the means of travel from forest cover field maps.

Field Procedures

Tie-point Establishment

Establishing a tie-point enables the short- and long-term relocation of a sample by subsequent field sampling crews. The tie-point and field notes provide another means of locating the sample in case the sample cannot be located using GPS data. The tie-point and navigation notes also allow other groups that may not have GPS to access the sample plot.

Establish the tie-point using the following procedures:

1. Confirm the tie-point location or select an alternative.
2. Mark the field photo and field map:
    - Locate the selected tie-point and pinprick the location on the field photo.
    - Locate and mark the tie-point, access point if appropriate, and ground plot center on the field map.
    - Record the following information on both the map and the back of the photo: project identity, ground plot number, crew initials, date and azimuth, directions and distances from tie-point to plot center.
    - ***Note*:** The tie-point must be placed in its relative position on the map. It is not enough to specify a road junction on both the photo and map without making sure that the map is accurate in its relative placement of that road junction.
3. Select a tie-point tree of suitable size so that the stem will be present for several years (not beside a road where it may be removed during road maintenance):
    - If possible, the tree should be > 20 cm in diameter.
    - Choose conifers over deciduous.
    - Where no suitable trees are available, use another feature, such as a rock cut or boulder.
    - A small rock cairn can aid relocation.
4. Record the species and diameter of the tie-point tree.
5. Measure the bearing and horizontal distance from the face of the tie-point tree to the tie-point.
6. Mark the tie-point tree for relocation of the samples in the short term (5–10 years):
    - Make the tie-point visible to a field crew conducting surveys, but not overly visible to the general public (e.g., select a tree that is a short distance from a road edge where it is not readily seen by the general public).

- Limb the complete stem to shoulder height.
- Remove understory vegetation around the tree, if practical.
- If appropriate, blaze the tree above breast height taking care not to girdle the tree.
- Spray paint the blazed surfaces.
- Ribbon the tree bole.
- Securely nail an aluminum identification tag with aluminum nails to the tie-point tree. If practical, the tag should face the tie-point location and be at the base of the tree below potential felling height.

Note: If establishing a ground plot in a park, other designated protected land, or private land, follow hidden plot procedures (Appendix C). The project manager will have an agreed-upon set of procedures to follow on private land or parks.

7. Collect GPS data at the tie-point location and record the file identification:
   - When GPS data cannot be collected, move to an area where data can be collected (such as an opening).
   - Measure the distance and bearing from the point where GPS data were gathered, back to the tie-point, and record.

Access Point

In some instances, the tie-point will not be directly accessible. For example, the crew may need to land by helicopter at an opening in a swamp and navigate to the tie-point using rough bearings and distances, or the crew may walk to the corner of a logging cutblock and then traverse from this point. If this is the case, the field crew should note the route traveled from the access point to the tie-point, in enough detail to aid relocation by a different crew for ongoing measurement in about 5–10 years.

The access point should be a long-term identifiable location (e.g., the junction of a highway and a secondary road, a creek crossing on a main logging road). Access notes should include the following:

- a description of the access location
- the bearing(s) and distance(s) from the access point to the tie-point
- GPS location data.

Reference Point

Establishing a reference point eliminates potential small-scale bias for the ground plot center location and aids in relocating ground plot center for ongoing measurement.

Reference Point Navigation

From the tie-point, navigate towards ground plot center using the following procedures:

1. Traverse from the tie-point along the pre-determined azimuth direction, towards the location of the sample plot center, using appropriate field methods (e.g., compass and nylon survey chain). Use offsets to traverse around unsafe or difficult situations.

2. Keep detailed notes of bearings and distances traveled, correcting all measured distances to the horizontal.

3. Flag the tie line well enough to be easily followed. Flagging is to aid in short-term relocation of the sample plot center (within one field season).

4. Stop 15.00 m short of the full distance. For example, if ground plot center is 380 m from the tie-point, stop at 365 m. Evaluate this location for reference point establishment:

    a. Confirm that the air photo and ground location agree. If they do not agree, evaluate the problems and find the correct sample location.

    b. There are a number of possible source of error:

        i. the wrong starting point

        ii. an incorrect bearing

        iii. the wrong compass declination

        iv. a significant local magnetic attraction

        v. error in base map.

    c. Possible solutions include:

        i. return to the tie-point and re-run the tie line;

        ii. select another tie-point and traverse from this point to the sample; and

        iii. if the original calculations are in error, you may be able to establish the location relative to known features near you and calculate the distance and bearing to the correct location.

5. ***Note:*** The objective is to **find the correct location on the ground as per the given UTM coordinates** of the sample point. You will not be "moving" the plot location if there is a conflict—you will be "finding" it. The map, GPS, and other tools are aids in finding the correct location.

Reference Point Establishment

Once you have determined that the air photo and ground location agree, establish and mark the reference point and tree. In standard forest conditions, the reference point and reference tree will be marked as follows:

1. At the reference point, drive a pin firmly into the ground until it is level with the ground surface. If appropriate, establish a small rock cairn over the pin location.

2. Choose a suitable reference tree (> 20 cm in diameter, if possible). The reference tree should be reasonably close to the reference point, in relatively good health, with a high probability of survival, and with particular distinguishing features when possible (such as a forked tree, spruce in an aspen stand, veteran in an immature stand). The reference tree should not be a tree in the sample plot.

3. Record the reference tree details (i.e., species, diameter, distinguishing features).

4. Mark the tree with flagging tape and paint above dbh.

5. Nail a pre-numbered aluminum tag to the base of the tree below where the tree would be cut if it were harvested, and facing the reference pin. If site conditions make this impossible, the tag location is at the discretion of the crew. Scribe the tag and record the tag number as part of the plot information.

6. Measure the bearing and distance from the tag on the reference tree to the reference pin.

7. ***Note:*** If the sample occurs in a park, other designated protected area, or private land, the project manager will designate that hidden plot procedures (Appendix C) be employed.

Ground Plot Center

From the reference pin, accurately measure the remaining 15.00 m, along the correct bearing, to the plot center to eliminate any possible small-scale bias in placing the center. If you have to offset the measuring tape for a local feature, reverse the offset to get back on line. The point 15.00 m from the reference pin is the ground plot center. This point becomes the plot center regardless of the site or conditions. The plot center may be in a small wetland, on a large rock, in a creek, or inside a standing tree.

Note: If the site location is inaccessible, unsafe, or poses an undue hazard, follow the guidelines for handling unavailable and difficult access plots (Appendix D). Collect as much information as possible. The project supervisor will review other means of completing all or some of these hazardous plots.

Plot Center Pin Establishment

Establish the ground plot center as follows:

1. Drive a pin or stake firmly into the ground at the sample plot center. If site conditions make it impossible or inappropriate to imbed the stake at the sample plot center, place it as close as possible to the plot center, and record the offset distance and bearing from the pin to the plot center. **All measurements are based on the initial selected pin location.**

2. Collect GPS data at the sample plot center. When GPS data cannot be collected at the plot center, move to an area where data can be collected, such as an opening. Measure the distance and bearing from the point

where data were collected back to the sample plot center. Record these measurements.

Completing the Header Information Field Cards (1a and 1b)

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have a measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Reference Tree – Sample Tag Number:** Record the tag number affixed to the base of the Reference tree.

6. **Field Responsibility:** Record the full name of the crew member responsible for the Tree Data and the crew member responsible for the Ecological Data.

7. **Field Check By:** Record the full name(s) of the auditor(s) that checked the field measurements for the tree data and/or the ecological data.

8. **Date of Field Check:** Record the date the audit of the field measurements was undertaken.

9. **Office Check By:** Record the full name(s) of the auditor(s) that checked the field cards in the office for the tree data and/or the ecological data.

10. **Date of Office Check:** Record the date the audit of the field cards was checked in the office.

11. **Plot Data Record**: Record the data fields that were completed with a check mark and the number of photographs that were taken at the sample.

12. **Ground Photos:** Record the ground photos that were taken with a check mark.

13. **Notes:** Record any general or access issues that were encountered in the completion of the sample.

14. **Access Notes:** Record on Field Card 1b the directions from a known location such as a highway junction to the sample plot tie-point. Use odometer readings to mark the locations of landmarks to aid in relocation of the ground plot. The access route can also be mapped on Field Card 1b.

Completing the Compass Information Field Cards (2a and 2b)

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have a measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Map Number:** Record the forest cover map number (note the number may be different for the tie-point and the plot center).

6. **Flight Line:** Record the flight line of the aerial photo used in accessing the sample plot.

7. **Photo Number:** Record the photo number of the aerial photo used in accessing the sample plot.

8. **Access Point Location:**

   a. Record a short description of the access point. If no access point was necessary, then record a note such as "none required: N/A."

   b. Record the Access Point GPS file ID number for the access point.

   c. Record the corrected UTM coordinates taken from GPS for the Northing, Easting, and elevation (m) of the access point.

9. **Tie-point Tree Detail and Location Data:**

   a. **Tie-point Tree Genus:** Record the genus of the tie-point tree using the first four letters of the scientific genus name. Tree species and their codes are in Appendix E.

   b. **Tie-point Tree Species:** Record the species of the tie-point tree using the first three letters of the scientific species name.

   c. **Tie-point Tree Variety:** Record the variety of the tie-point tree (if applicable) using the first three letters of the scientific variety name.

   d. **Tie-point Tree dbh (cm):** Measure and record the dbh to the nearest 0.1 cm of the tie-point tree.

   e. **Azimuth (°):** Record the azimuth from the tie-point tree to the tie-point location. In some instances, the tie-point tree may be the same point (record N/A).

   f. **Distance (m):** Record the distance, to the nearest 0.01 m, from the tie-point tree to the tie-point location. In some instances, the tie-point tree may be the same point. If the tie-point is also the tie-point tree, 0.0 m should be the distance recorded.

g. **Tie-point Tree – Sample Tag Number:** Record the tag number affixed to the base of the Tie-point tree.

h. **GPS Tie-point File ID Number:** Record the GPS file number for the tie-point.

i. **UTM Coordinates and Elevation (m):** Record the corrected UTM coordinates taken from GPS for the Northing, Easting, and elevation (m) of the tie-point.

10. **Reference Point Tree Details and Location Data:**

a. **Reference Point Tree Genus:** Record the genus of the Reference Point tree using the first four letters of the scientific genus name. Tree species and their codes are in Appendix E.

b. **Reference Point Tree Species:** Record the species of the Reference Point tree (if applicable) using the first three letters of the scientific species name.

c. **Reference Point Tree Variety:** Record the variety of the Reference Point tree (if applicable) using the first three letters of the scientific variety name.

d. **Reference Point Tree dbh (cm):** Measure and record the dbh of the Reference Point tree. In some instances, there will be no trees at the site, so a stump or other feature may be required (record in the comments what feature was used as a reference feature).

e. **Azimuth (°):** Record the azimuth from the Reference Point tree to the reference pin location.

f. **Distance (m):** Record the distance, to the nearest 0.01 m, from the Reference Point tree to the reference pin location.

g. **Offset Reference Pin:**

i. **Azimuth (°):** Record the azimuth from the offset reference pin to the actual reference location.

ii. **Distance (m):** Record the distance, to the nearest 0.01 m, from the offset reference pin to the actual reference location.

11. **Straight Line Bearing and Distance to Plot Center:**

a. **Azimuth (°):** Record the azimuth bearing (0 to 359°) from the tie-point to the sample plot center.

b. **Distance (m):** Record the distance to the nearest metre from the tie-point to the sample plot center.

c. **Declination (°):** Record the declination in degrees used to establish the sample plot.

12. **Navigation Notes and Map Area:** To aid in relocation, sketch the features encountered from the tie-point to the sample plot location.

4.5 Ongoing Measurement Procedures

Office Preparation

- Obtain copies of the original field cards, notes, aerial photographs, and maps.
- Obtain new forest cover maps and aerial photography for the area as needed for relocating the established plot.
- Review maps and photography and note any disturbances, land cover changes, or access issues since the last measurement.
- Confirm land status.
- Obtain permission to sample plots located on private land.

Access and Tie-Points

- If necessary, revisit the access point and remeasure attributes.
- If necessary, due to logging or other disturbances, a new access point may need to be established. Collect GPS data at this point to assist in long-term relocation.
- Traverse to the tie-point. Revise access and tie-point notes as necessary.
- Revisit the tie-point and remeasure attributes. Mark the tie-point tree as necessary to facilitate the relocation of this point in a 10-year time frame.
- If necessary, due to logging or other disturbances, a new tie-point tree may need to be established. Follow procedures for the establishment of the tie-point tree.
- Collect GPS data at this point to assist in ongoing measurement.

Reference Point

- Traverse to the reference point using traditional methods.
- Mark the access line with ribbon for short-term access as necessary.
- Mark the reference point tree as necessary to facilitate the relocation of this point in a10-year time frame. Remeasure the attributes for the reference tree.
- Re-establish the reference pin if necessary (if the pin is out of the ground or disturbed). Follow procedures for the establishment of the reference pin.
- If necessary, due to logging or other disturbances, a new reference point tree (or stump) may need to be established and attributes collected.

Plot Center Pin

- Remeasure the distance from the reference point to the plot center pin.
- Re-establish the plot center pin if necessary (if the pin is out of the ground or disturbed).
- If the plot center pin cannot be relocated after a diligent search, it will be necessary to re-establish the plot center pin at the correct UTM coordinates. This may involve the full re-establishment of the tie-point through to pin location or only a portion of the process. Measure the new plot as established.
- If the plot has been converted to another land use (such as an agricultural field), then re-establish where the plot center would have been located and temporarily establish the plot center pin. Measure the attributes that are still present such as soils information, woody debris, remaining trees, and vegetation. Record notes and photographs that describe the disturbance.
- Collect new GPS data at the plot center pin to confirm the location.

5.0 Plot Establishment and Sequence of Measurements

5.1 Introduction

This section outlines the layout of plot and measurement procedures at the ground plot center. For more detailed procedures, refer to the appropriate sections.

5.2 Objectives

- To establish sample plots for the National Forest Inventory (NFI).

5.3 Definitions

The NFI sampling design is a single cluster with an integrated plot at the center of the cluster. The location of the cluster is at a pre-determined grid point on the center point of a selected photo plot.

The plot center is the location around which the detailed sample information will be collected. All attributes are attached to the plot center point. Data are collected on the following major items using the sampling methods listed.

Table 5.1 Summary of data collected at the plot center and the sampling method employed.

Data	Plot type
Woody debris	30-m line transects (2)
Surface substrates	Points on 30-m line transects
Vegetation attributes	Fixed-area plots (10- and 5.64-m radius)
Soil attributes	Soil pit
Biomass and soil bulk density	4 fixed-area plots (0.56-m radius) at the ends of the transects
Large tree attributes	Fixed-area plot (11.28-m radius)
Site tree data	Fixed-area plot (11.28-m radius)
Small tree/shrub data	Fixed-area plot (3.99-m radius)
Stump data	Fixed-area plot (3.99-m radius)
Site information	Fixed-area plot (11.28-m radius); visually estimated plot (approximate 25-m radius)

5.4 General Procedures

1. Confirm that the plot center is in the correct location.
2. Assess safety considerations.
3. Determine and carry out the sequence of measurements.
    - Assess the site vegetation and determine the most efficient sequence of measurements to ensure that specific values are not degraded by other activities.
    - Establish transects and fixed-radius plots as per selected sequence.
4. Record the plot characteristics (e.g., project identification details, network label, dates, crew members, plot areas or transect lengths).

Field Cards for Plot Establishment

Cluster Diagram (3) (Appendix B, Diagram 4)
Field card for recording ground plot site features.

Ground Plot Site Information (15) (Appendix B, Diagram 22)
Field card general site data: province, terrestrial ecozone, UTM coordinates, slope, aspect, land base, land cover, land position, vegetation type, density class, stand structure, successional stage, elevation, plot tree origin information, plot tree treatment information, plot tree disturbance information.

General Site Establishment

Unavailable and Difficult Access Plots

In some cases, a plot (or some part of it) may be unavailable because of factors such as denied access or physical safety concerns. A field crew is not expected to sample beyond what is considered reasonable and safe. **The safety of the field crew is the first priority.**

Guidelines for handling unavailable and difficult access plots should be followed (see Appendix D) and as much information as possible should be completed on the field records to the stage where fieldwork was terminated. When all or part of a plot is dropped, advise the project manager. Take detailed notes as to why the plot was not established. Examples include:

- access to the plot was too dangerous;
- plot was in an unsafe or inaccessible area (e.g., steep cliffs, swift-flowing creek); and
- permission to access private land was denied.

Partial Plots

NFI ground plots are only established in forested areas and are used to gather detailed information of the site conditions of Canada's forested land base. Ground plots should be measured in full, unless one of the following situations is encountered:

1. hazardous situation
2. plot falls partially out of forested polygon.

When one or both of these situations is encountered at a plot, the guidelines for handling partial plots should be followed (Appendix D).

Plot Marking

National Forest Inventory ground plots are monitored to assess change in the forested landscape. To ensure plots do not receive special treatment, plot markings such as tree tags, field ribbons, painted tree numbers, paint on logs, and ground should be minimized or placed where they are not readily visible.

Field Equipment

Appendix F identifies each ground plot sampling component and the sampling equipment necessary to complete the field measurements.

Timing and Order of Measurements

Measured attributes include annual plants, which are included in estimates of biomass and biodiversity. Therefore, measurements should be taken when the plants are fully developed, and toward the end of the normal, tree-growing season. These two constraints create a small window of opportunity for fieldwork. If fieldwork is impossible during that period, efforts must be made to be consistent in the timing of successive measurements. For example, if plot measurements are taken in June at the time of plot establishment, they should also be taken in June at the time of subsequent measurements.

To avoid trampling herbaceous vegetation during fieldwork, vegetation cover should be estimated as soon as possible after plot establishment. Generally, this means starting with the Ecological Plot, followed by the transects and associated microplots, the Large Tree Plot, Small Tree Plot, and finally the site assessment. As the soil pit is generally located outside of the Large Tree Plot, measurements should be completed at any time after the assessment of the surface substrate.

Establishing the Sample Plots and Line Transects

The following is a typical work sequence for establishing the NFI sample plots and line transects after the plot center pin has been established. The field crews will usually complete the layout of the fixed-radius plots concurrently. The details of plot and transect establishment are discussed in more detail in the following section and in the coming chapters (Figure 5.1).

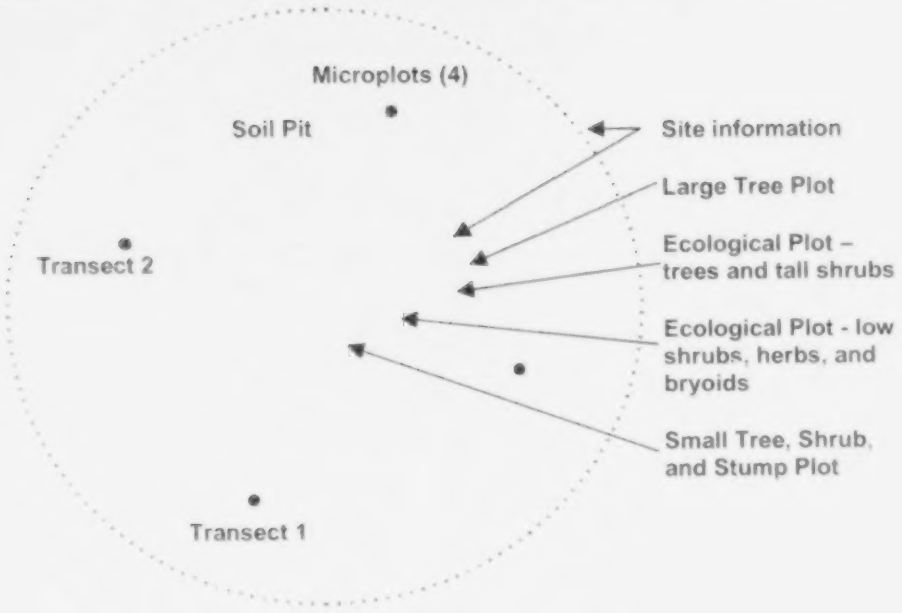


Figure 5.1 NFI ground plots.

The following is a suggested order for plot establishment:

- GPS data are collected to confirm sample location.
- Ecologist starts listing of plant species around plot center.
- Two persons on crew establish various plots and transects
  - Establish and mark the line transects. The crew usually places two Eslon measuring tapes (secured at either end of the transect) on or close to the ground on the pre-determined bearings.
  - Measure and mark quadrant lines with ribbon markings at 5.64, 10.0, and 11.28 m.
  - Measure and mark sector lines with ribbon markings at 5.64, 10.0, and 11.28 m.
  - Measure and mark any intermediate points between the sector and quadrant lines as needed on 5.64- and 10.0-m plots.
  - The 5.64- and 10.0-m Ecological Plots should now be fully marked.
  - As the 11.28-m tree plot is being marked, measure any borderline trees along the plot boundary.

- At this point, the Ecological Plot boundaries, Large Tree Plot boundary (with sectors), and transects have been established. The ecologist and other members of the crew can now see the areas of the various plots and transects and take extra care not to disturb these locations as other work progresses.

  - Often, the Small Tree Plot is established after the ecologist has completed the plant cover estimates as the extra plot radius marking may add confusion to the already busy site.

  - The soil pit is established outside the 11.28-m tree plot and the proper placement is determined after the surface substrate has been measured. Therefore, the soil pit is located later in the sequence.

  - Site information is generally assessed last, when everyone has a thorough knowledge of the site. Disturbance, treatment, and origin information are related to data collected within the boundaries of the Large Tree Plot and should therefore be interpreted within the boundaries of the Large Tree Plot. Other site information (e.g., slope, landscape position, succession stage) may require a larger area for interpretation; though no fixed-plot size is necessary, a radius of 25 m around plot center is suggested as a reasonable area from which to interpret these features.

The typical sampling crew will consist of an ecological sampler, timber sampler, and one or two assistants that can help either sampler. The activities will occur at the same time and coordination of activities is essential in completing the samples in a timely and efficient manner. Crew members should be able to assist in completing all aspects of the sample.

The preceding sequence of events can change significantly dependent upon site conditions. For example, the number of large trees encountered in past samples has ranged from no trees to over 300 trees within the plot (the time to complete the Large Tree Plot has varied from 5 min to > 10 h). Similarly, the ecological plant list can vary from 5 to over 40 species. Each sample location and the sequence of establishing the plots will need to be evaluated once the crew is on site.

5.5 Detailed Procedures

Depending upon the sequence of measurements selected, perform the following functions:

Establishing the Plots at the Plot Center

Woody Debris and Surface Substrate Transects

Transect 1: Establish a 30-m horizontal line transect at a pre-determined bearing, which bisects the plot center at 15.0 m along the transect (Figure 5.2).

1. Measure woody debris along this transect as follows:

   a. large coarse woody debris (> 30 cm diameter)

b. medium coarse woody debris (between 7.5 and 30.0 cm diameter)

c. small woody debris (between 1.0 and 7.5 cm diameter).

2. Make detailed measurements on the woody debris at the point of crossing the transect.

3. Measure surface substrate along the transect at every 2 m in mineral soils and at every 4 m in deep organic soils.

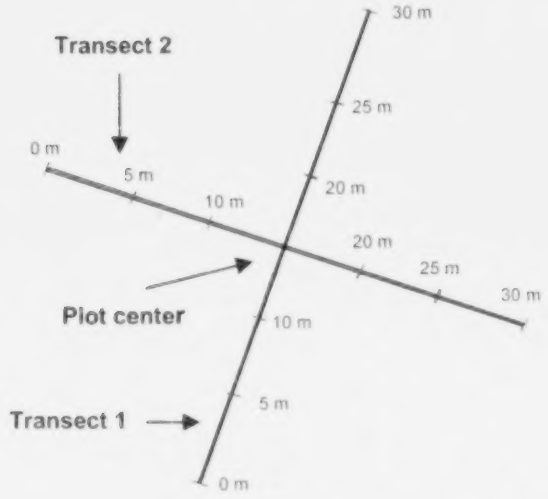


Figure 5.2 NFI woody debris and surface substrate transects.

Transect 2: Establish a second 30-m transect through the plot center at plus 90° from the first line transect. Transect should bisect plot center at 15.0 m.

1. Measure woody debris along Transect 2.

2. Measure surface substrate along Transect 2.

Ecological Plots

Establish a 5.64- and 10.0-m fixed-radius plot, centered at the plot center pin (Figure 5.3).

- Record the percent cover of each species occurring in each ecological layer.

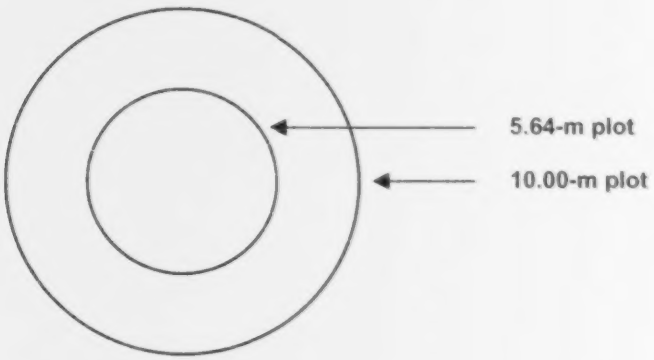


Figure 5.3 NFI Ecological Plots.

Soil Pit Establishment

A representative site will be determined outside the 11.28-m Large Tree Plot but within the 25-m radius area for excavation of a soil pit. Soil attributes will be measured and recorded from this pit.

The soil pit should be representative of the soils at and immediately surrounding plot center. To assist in determining the best representative location for the soil pit, first complete the surface substrate measurements along the transects. Soil pits are ≥ 60 cm deep, unless bedrock or a water table is encountered before reaching this depth (depth starting at surface of the mineral soil). In deep organic soils, the soil pit should be excavated to a minimum depth of 100 cm when possible.

Microplot Establishment

1. Establish four 1-m^2 microplots at the ends of the line transects. Each microplot has a 0.56-m radius. Microplots are numbered clockwise from the 0 m end of Transect 1 (Figure 5.4).

2. Collect aboveground biomass samples, forest floor samples, and bulk density samples.

Figure 5.4 NFI microplots.

Large Tree Plot

Establish an 11.28-m fixed-radius plot centered at the plot center pin (Figure 5.5) for trees ≥ 9.0 cm.

1. Subdivide the Large Tree Plot into eight sectors, numbered 1 to 8. Mark a line due north and due south through the plot center. Mark a second line due east and due west through plot center. This divides the plot into four quadrants. Subdivide each of the established quadrants at 45° from the cardinal bearings. There now will be eight sectors (Figure 5.6).

2. Number the sectors from 1 to 8, starting from north and proceeding in a clockwise direction.

3. Number the trees sequentially clockwise in sectors starting from the north.

4. Make detailed measurements on the selected "in" large trees.

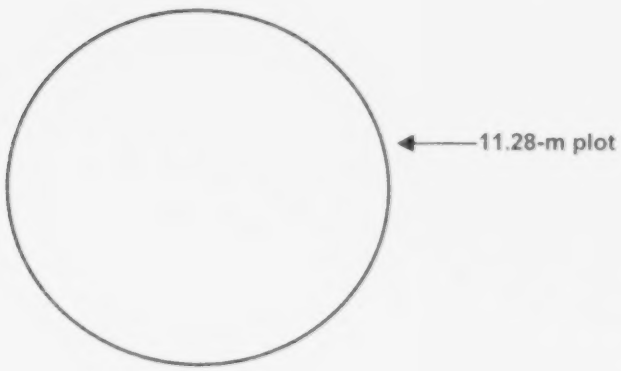


Figure 5.5 NFI Large Tree Plot.

Site Tree Selection

1. Measure a top height tree, if a suitable tree is available in the northeast quadrant of the Large Tree Plot.
2. Determine the species composition (by basal area for large trees and by stem count for small trees) for the sample plot.
3. Measure a site tree of the leading, second, and other major species if available in each quadrant.
4. Select and measure additional site trees as required.

In most cases, the top height tree will also be either a leading, second, or other major species site tree. Sometimes, the top height tree may be another species other than the above selections.

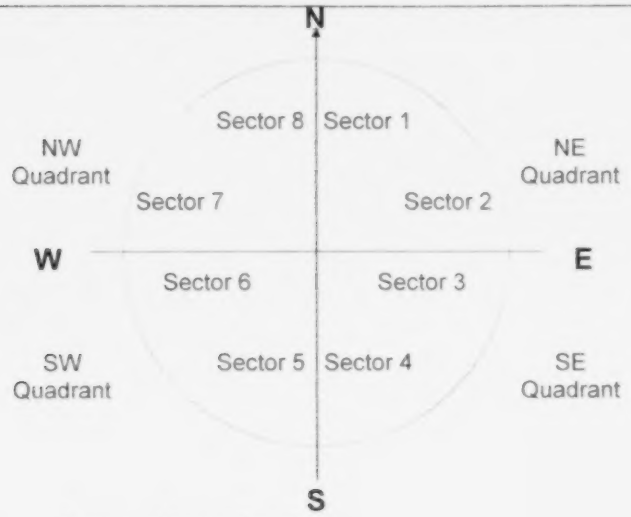


Figure 5.6 **Layout of Large Tree Plot.**

Small Tree, Shrub, and Stump Plots

Establish a 3.99-m radius plot centered at the plot center pin (Figure 5.7) for trees ≥ 1.3 m in height to < 9.0 cm at dbh, for shrubs ≥ 1.3 m in height, and for stumps with top diameters inside bark of ≥ 4 cm.

1. Make detailed measurements on the selected "in" small trees.
2. Make detailed measurements on the selected "in" shrubs.
3. Make detailed measurements on the selected "in" stumps.

Figure 5.7 **NFI small tree, shrub, and stump plot.**

Ground Plot Site Information

Disturbance, origin, and treatment information should be interpreted from within the boundaries of the Large Tree Plot. For other site features, it is acceptable to visually establish a 25 m (approximate) radius plot around the plot center pin and estimate features from within that area (Figure 5.8).

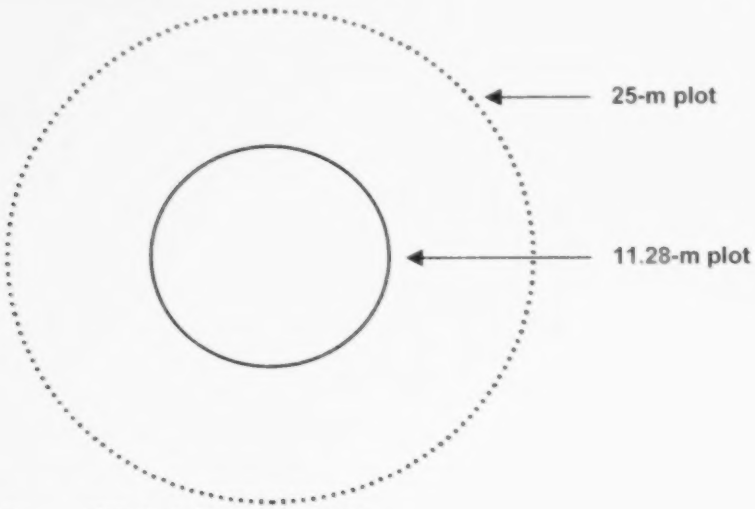


Figure 5.8 NFI site information plot(s).

5.6 Ongoing Measurement Procedures

Plot Splitting No Longer Acceptable

On the initial sample installation, some jurisdictions split some of the plots due to workload (cost) issues. A plot that was split because it had too many trees in the installation phase may be harvested before the next remeasurement. It would now be more suitable to measure a full plot at this time. This results in statistical issues when compiling data from partial plots at one cycle and full plots at the next cycle.

Because NFI plots will be established and remeasured in perpetuity, and most samples are going to change dramatically throughout the sampling time frame, all plots will be established as FULL plots on initial installation or ongoing measurement (except for areas with safety concerns).

Upon remeasurement of plots that were split in the initial measurement, it will be necessary to:

- Re-establish and measure the portion of the plot as established on the original sample. Keep these data separate. The data collected from this measure can be used to derive change from the previous measure.
- Establish a full plot with the complete plot data kept separate. The full plot data will be compiled in the office. At the next remeasurement cycle, the full plot will be measured for change.

Unavailable or Difficult Access Plots

During the initial installation phase, some samples may not have been completed or only a portion completed as the site was unavailable or difficult to access. The project manager will review all selected initial sample locations at each ongoing measurement cycle to determine if the site is still unavailable for sampling. Some of the sample locations may now be available and would be established. In other instances, the site may no longer be available and would not be measured.

- If the plot cannot be safely accessed due to a new long-term danger, the crew should document the safety concerns and not attempt the sample measurement. These samples will be recorded as non-response samples.
- Samples having a short-term danger issue, such as a bear in the area, can be revisited at an alternate safe time.
- If a crew is denied access to private land, the sample crew should document the issue for the project supervisor. These samples will be recorded as non-response samples. The project manager should reconsider sampling the location at each ongoing measurement cycle (Appendix D).

Establishing the Sample Plots and Transects for Ongoing Measurements

Woody Debris and Surface Substrate Transects

Re-establish the two 30-m line transects along the pre-determined bearing.

1. Measure woody debris according to procedures.
2. Sampling for surface substrate should be offset for ongoing measurement.
    - Stations for the first ongoing measurement of surface substrate will be located 0.5 m offset from the original locations at 29.5, 27.5, 25.5, 23.5, 21.5, 19.5, 17.5, 15.5, 13.5, 11.5, 9.5, 7.5, 5.5, 3.5, and 1.5 m (Figure 5.9).

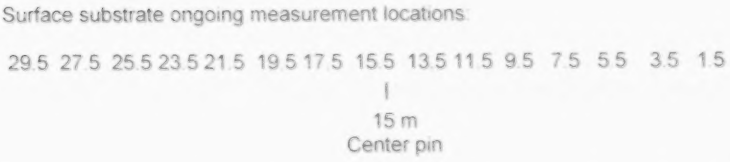


Figure 5.9 **First ongoing measurement station setup for surface substrate measurements.**

- In deep organic soils, sampling should occur every 4 m along the transects. At first ongoing measurement, the locations are located 0.5 m offset at 29.5, 25.5, 21.5, 17.5, 13.5, 9.5, and 5.5 m.
- Stations for the second ongoing measurement of surface substrate will be located 0.5 m offset from the original locations at 28.5, 26.5, 24.5, 22.5, 20.5, 18.5, 16.5, 14.5, 12.5, 10.5, 8.5, 6.5, 4.5, 2.5, and 0.5 m (see Section 8.6: Ongoing Measurement Procedures for Surface Substrate.

below). Stations for the third ongoing measurement will be in the original locations.

- In deep organic soils, sampling should occur every 4 m along the transects in the same design as above.

Ecological Plots

Establish 5.64- and 10-m fixed-radius plots centered at the plot center pin to collect a vegetation list and cover values for species at each layer (see Figure 5.3).

Soil Pit

The soil pit will not be remeasured in ongoing measurement plots unless the information was not collected in the original plot or there has been a major disturbance (i.e., landslide, major flooding, severe fire, mechanical damage, soil movement). A major disturbance should be one that is extensive enough to alter the soil and vegetation establishment of the survey site (≥ 25-m radius). If the disturbance only affects a portion of the survey site, the disturbance must have affected a major portion of the plot and/or adjacent area, which may influence the plot (i.e., drainage into or out of plot).

Microplots

1. For ongoing measurement, a new set of microplots will be established for biomass and bulk density sampling using the line transects.

    - For the first ongoing measurement, establish the microplots 2 m clockwise from the original set and 15 m from the plot center (Figure 5.10).

    - For the second ongoing measurement, establish the microplots 2 m counter-clockwise from the original set and 15 m from the plot center (Figure 5.10).

    - For the third ongoing measurement, establish the microplots 2 m farther away from plot center than the original set (17 m from the plot centre) (Figure 5.10).

    - For the fourth ongoing measurement, establish the microplots 4 m clockwise from the original set of microplots and 15 m from the plot center locations (Figure 5.10).

    - For the fifth ongoing measurement, establish microplots in the original locations.

2. Collect aboveground biomass samples, forest floor organic samples, and bulk density samples.

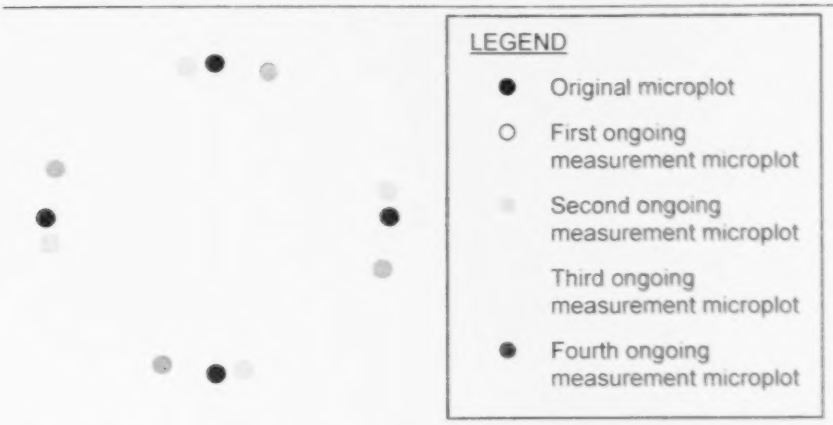


Figure 5.10 Locations of the ongoing measurement microplots.

Large Tree Plot

Establish an 11.28-m fixed-radius plot centered at the plot center pin (Figure 5.5) for trees ≥ 9.0 cm and larger.

1. Establish the eight sectors for the Large Tree Plot.
2. Number any new trees sequentially clockwise in sectors starting from the north.
3. Make detailed measurements on the selected "in" large trees.

Site Tree Selection

1. Remeasure a top height tree, if a suitable tree is available in the northeast quadrant.
2. Determine the current species composition (by basal area for Large Tree Plots and by stem count for Small Tree Plots) for the sample plot.
3. Measure the leading species site trees, second species site trees, and other major species site trees, if available, in each quadrant.
4. Select and measure additional site trees as required.
5. Site trees cored in previous measurement cycles that have received an excellent, good, or fair rating from the lab do not need to be cored again. Core samples are required for new site tree selections as well as any site trees cored in the previous measurement cycle that received a poor, very poor, or N/A rating from the lab.

Small Tree, Shrub, and Stump Plots

Establish a 3.99-m radius plot centered at the plot center pin (see Figure 5.7) for trees ≥ 1.3 m in height to < 9.0 cm at dbh, for shrubs ≥ 1.3 m in height, and for stumps.

1. Make detailed measurements on the selected small trees.
2. Make detailed measurements on the selected shrubs.

3. Make detailed measurements on the selected stumps.

Ground Plot Site Information

Interpret site origin, treatment, and disturbance information from within the boundaries of the Large Tree Plot. For other site features, it is acceptable to visually establish a 25-m (approximate) radius plot around the plot center pin and estimate features from within that area

6.0 Ground Plot Photographs

6.1 Introduction

At each ground plot, eight photographs are taken and digitally stored. These photos are useful for potential users who may want to subsample on these locations for other values, capturing information that has not been measured directly (e.g., assessing vegetation competition), serving for comparison during ongoing measurement, and providing reference or clarification to future NFI users.

6.2 Objectives

- To document sample conditions not readily measured through data collections.
- To assist in the relocation of the plots.
- To enable other users to select potential sites for further research.
- To document unusual situations.

6.3 General Procedures

1. Prepare plot identification cards and gather measurement items for scale references.
2. Take plot ground photographs before most field disturbance activities.

Field Cards for Ground Plot Photographs

Header Information (1a) (Appendix B, Diagram 1)
Plot Header Field card: network label, crew names, measurement date, ground photos.

6.4 Detailed Procedures

Using a digital camera, take eight photos at each NFI ground plot site (more photos may be required if anomalous conditions are encountered) using the following procedures:

1. Do not cut trees or vegetation to provide an unobstructed view.
2. Take photos before taking measurements, especially if the site could be damaged during sampling.
3. Each photo should have the sample number written on a label with lettering that is ≤ 7 cm in height. It is suggested to have a "whiteboard" on which the information can be written and reused for each photo. Each close-up photo should include labels with the following:

    a. photo number

b. network label

c. photo description (e.g., "soil pit", "plot center")

Note: To save time in the field, write labels in advance.

4. Try to include tools in each photo for scale. Lay out the transect tapes before taking the transect photos. Use a scale in any close-up photos.

   - *Note:* If field crew members are captured in an image, they **must** sign a Photo Release Form (see Section 6.5).

5. Record the photos taken (photo number) and any comments on the Header Information field card.

6. The following photographs are to be submitted to the NFI program in digital format, complete with the network label, photo number, and description of the photos:

   - **Photo 1:** Photograph the plot center pin at a steep angle (about 60°) above the pin so that the pin and approximately 1 m of ground and vegetation can be seen.

   - **Photos 2–5:** Each transect line will have two photos showing the lines extending from plot center (0–15 m and 15–30 m), resulting in four photographs. Take the photographs with measuring tapes in place, from a position behind the plot center pin. Include the plot center pin in the foreground. Include something for relative scale determination. Try to include the various crown levels with a "portrait" (vertical) format, if required.

   - **Photo 6:** Representative photo. Photograph the vegetation in the plot that the crew considers representative of the sample vegetation and stand structure at the plot center pin. Include an item for scale in the photo.

   - **Photo 7:** Photograph the forest canopy directly overhead, at the plot center pin.

   - **Photo 8:** Photograph the soil profile that has been described at the pit. Make sure a tape measure or metre stick has been placed up against the profile with the 0 cm mark starting at the ground surface. Photograph the profile face from outside the pit, preferably with the sun behind the photographer shining on the exposed profile.

   - *Note:* Photograph any other unusual features that you think would be of interest to users of these data. You may wish to illustrate issues about the sampling process, such as when rules do not seem clear or appropriate. Record descriptive notes in the comments section for these photos so that issues can be addressed later.

Examples of the required photographs are illustrated in Figures 6.1–6.5.

Figure 6.1 **Example of ground plot center photo (Photo 1).**

Figure 6.2 **Example of transect photo (Photos 2–5).**

Figure 6.3 **Example of representative photo (Photo 6).**

Figure 6.4 **Example of overhead photo (Photo 7).**

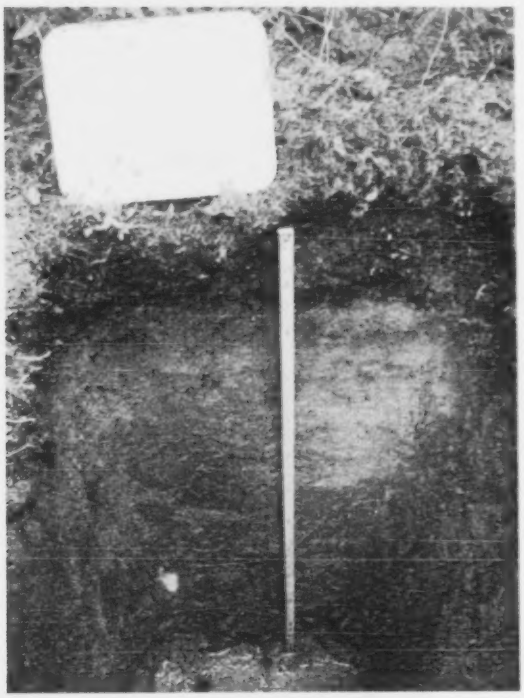


Figure 6.5 Example of soil pit photo (Photo 8).

6.5 Ground Plot Photo Release Form

All ground plot photos will be publicly available on the NFI Web site. Therefore, all individuals captured in any photos must sign a "Photo Release Form" annually (Appendix G). Project managers must acquire a photo release from all crew members or others that may appear in an image.

6.6 Ongoing Ground Plot Photographs

For each measurement date, collect new photographs of items number 1 to 7 as described in the initial plot establishment process.

For ongoing measurement samples, photograph number 8 of the soil pit will be dropped unless a new soil pit is established.

7.0 Woody Debris Measurements

7.1 Introduction

Woody debris is an important structural component of forest and stream ecosystems. It is linked to biodiversity and ecosystem processes by providing habitat for a broad range of organisms, contributing to energy flow and nutrient cycling, and influencing soil and sediment transport and storage in streams. There is a growing interest in the collection of woody debris information because of the increased recognition of its ecological importance. In addition, there is a need for quantitative data to guide forest management practices.

Woody debris measurements are collected to support NFI requirements for the measurement of total ecosystem carbon stocks. Woody material contributes to surface organic content. Four classes of woody debris are collected in the NFI: large coarse woody debris, medium coarse woody debris, small woody debris, and fine woody debris. Large, medium, and small woody debris measurements are described in this section. Fine woody debris will be physically collected from the microplots (see Section 11: Microplots). Data from all woody debris measurements will be used in analysis for reports on the criteria and indicators of sustainable forest management, biodiversity, forest health, and climate change.

7.2 Objectives

- To accurately determine the gross volume of woody debris by decay class.

7.3 Definitions

Woody debris (WD): Downed dead wood, which includes sound and rotting logs, odd-shaped woody pieces, accumulations, and uprooted stumps. It is usually described as dead, non self supporting, woody material in various stages of decomposition that is located above the soil. For this inventory, four sizes of woody debris have been defined:

- **Large coarse woody debris (LCWD):** Pieces > 30.0 cm (or equivalent cross-section) in diameter.
- **Medium coarse woody debris (MCWD):** Pieces > 7.5 cm and ≤ 30.0 cm (or equivalent cross-section) in diameter.
- **Small woody debris (SWD):** Pieces > 1.0 cm and ≤ 7.5 cm (or equivalent cross-section) in diameter.
- **Fine woody debris (FWD):** Pieces ≤ 1.0 cm in diameter. This will be measured in the microplots (see Section 11: Microplots).

7.4 General Procedures

1. Establish two 30-m line transects along pre-determined bearings.
2. Assess the transect conditions.

3. Measure and record information for woody debris pieces.

Field Cards for Woody Debris

Woody Debris Transect 1 (4a and 4b) (Appendix B, Diagrams 5 and 6)
Field card for Transect 1: species, diameter, decay class, tilt angle, accumulations, small woody debris.

Woody Debris Transect 2 (5a and 5b) (Appendix B, Diagrams 7 and 8)
Field card for Transect 2: species, diameter, decay class, tilt angle, accumulations, small woody debris.

7.5 Detailed Procedures

Establishing the Sampling Transects

Woody debris is measured along two horizontal, 30-m line transects established on pre-determined azimuths. For jurisdictions using random azimuths, refer to Appendix H for the determination of the random azimuth. The lines are established in an "X" pattern and intersect at the plot center. Transect establishment procedures are as follows:

1. Starting from plot center, walk 15 m from the plot center on the back-bearing for the transect. Align the bearing with the plot center by sighting through the plot center along the pre-determined azimuth. Establish Transect 1 by laying a plot tape from the origin to plot center (0–15 m), continue past the plot center to the end of the transect at 30 m. Correct all distances to horizontal distance (for instructions on calculating slope allowances, refer to Appendix I). Mark the ends of the transect with a large stick driven into the ground.

2. Mark the distance from plot center along the transects in 5-m increments (i.e., at 5, 10, 15 (plot center), 20, 25, 30 m). Increments can be marked with a small stick inserted in the ground, a piece of flagging ribbon (temporary marking for quality control), or a small paint mark on the ground.

3. Establish Transect 2 in a similar way, using the pre-determined azimuth (+ 90°) and correcting for slope. Mark the line as above.

Figure 7.1 **Transect layout and increment marking along transect.**

Assessing the Transect Conditions

Normally, the full length of the transect will be sampled. However, because the transects are based on a pre-determined bearing, unsafe or difficult conditions may be encountered and the crew may be unable to sample the full length. Possible transect conditions include:

- **Normal conditions:** Sample each transect fully using the procedures outlined in the following sections.
- **Anomalous conditions:** If the sample line intercepts an anomaly along the transect, such as a stream, pond, avalanche chute, or a rock outcrop, continue to sample the line as long as it is safe to do so. Portions of the transect may be dropped if the line enters a non-forested area (see Appendix D on Partially Forested Plots). If the debris is floating, the pieces are measured in their location at the time of sampling (note this in the comments section of the tally card).
- **Unsafe conditions:** If the sample line intercepts unsafe conditions, record the length of line section(s) actually sampled in the field. Note in the comments section why a portion was not sampled.

Sampling Woody Debris along the Transects

Sections of the Transects Sampled

Along each transect different sizes of woody debris will be measured in 5-m increments as follows:

- **0 to 5 m:** LCWD, MCWD, SWD
- **5 to 10 m:** LCWD, MCWD
- **10 to 20 m:** LCWD
- **20 to 25 m:** LCWD, MCWD
- **25 to 30 m:** LCWD, MCWD, SWD

Sequence of Measurements

1. Starting at the end of Transect 1 (0 to 5 m mark), measure and record woody debris attribute information for all LCWD and MCWD pieces (all woody debris $\geq$ 7.5 or equivalent cross-section). Also measure SWD, using a go-no-go gauge (see Figure 7.5 below), and complete the tally of SWD by size class.
2. For the next 5 m of transect (from 5 to 10 m), measure and record woody debris attribute information for all pieces of LCWD and MCWD.
3. From 10 to 20 m along the transect (through the plot center), measure and record attribute information for only the LCWD (> 30.0 cm in diameter or equivalent cross-section).
4. From 20 to 25 m, measure and record woody debris attribute information for all pieces of LCWD and MCWD.
5. For the last 5 m of the transect (from 25 to 30 m), measure and record attribute information for all three classes of woody debris.
6. Once the end of the transect is reached, turn around and take surface substrate measurements starting from the end of the transect, and working your way back towards plot center. Surface substrate measurements (Section 8) are taken **after** woody debris measurements to avoid disrupting woody debris along the line before it has been tallied.
7. Repeat procedures for Transect 2.

Which Woody Debris to Measure

Measurements along the line transects are taken on pieces of LCWD, MCWD, and SWD where the centerline of the woody debris intersects (under or over) the vertically projected transect. The centerline of the woody debris is the midline of any section of wood and may not correspond to the pith. If the transect line appears to follow the centerline of the woody debris, decide whether it is "measured" (transect line intersects centerline of woody debris) or "not measured" (transect line does not intersect centerline of woody debris) (Figure 7.2).

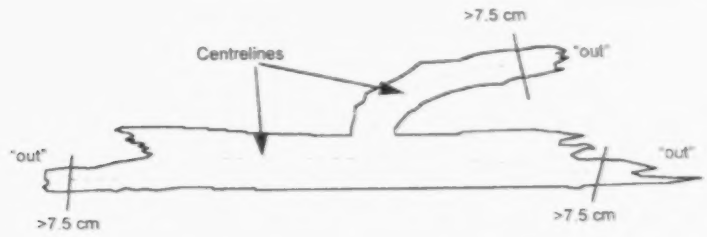


Figure 7.2 **Measure woody debris where the transect crosses the centerline of the piece.**

If the line transect intersects a curved or angular piece of woody debris more than once, measure each piece intersected as a separate observation (Figure 7.3).

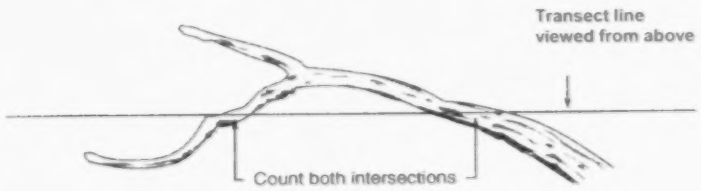


Figure 7.3 **Measure woody debris at each transect crossing.**

Measured woody debris includes the following:

- fallen or suspended (not self-supporting) dead tree boles, with or without roots attached;
- fallen trees with green foliage (no longer rooted to the ground);
- fallen trees broken into wood pieces or pieces of bark on the ground surface;
- fallen branches and fallen, broken tree tops that are horizontal or leaning;
- recently cut logs (may include bucked logs or log decks);
- woody debris is above the forest floor at the transect; and
- uprooted (not self-supporting) stumps and any exposed dead roots on the stump.

The following are not considered woody debris and are not measured:

- live or dead trees that are self-supporting (still rooted);
- live fallen trees;
- exposed roots of self-supporting live or dead trees;

- dead branches still connected to standing trees;
- self-supporting stumps or their exposed roots;
- wood that has decomposed to the point where it could be described as forest floor humus (< 50% above forest floor);
- decaying wood covered by accumulations of organic matter ≥ 1 cm thick;
- buried wood: woody debris below the surrounding surface; and
- if an organic layer has developed over the wood, the woody debris must have ≥ 50% of its thickness above the surrounding surface. Woody debris is considered no longer above the soil when it is entirely buried beneath a layer of surface organic matter (forest floor) ≥ 1 cm thick or mineral soil (Figure 7.4).

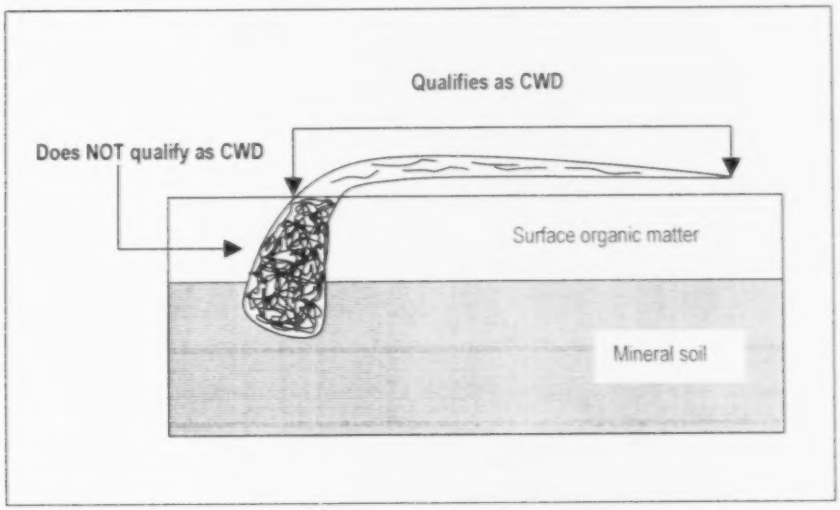


Figure 7.4 Side view of partially buried CWD.

Measuring Woody Debris

Without disturbing the pieces, mark each piece of CWD that crosses the transect line. The marking should be minimal such as small paint dots or ribbon to assist quality assurance only. Ensure pieces are not moved or damaged so that quality assurance checks and future remeasurements can be conducted. Some jurisdictions may nail a numbered tag (hidden on the lower side of the piece) at the point of intersection to woody debris pieces to assist in relocating the pieces.

Woody Debris – Round Pieces (LCWD and MCWD)

Round-shaped pieces include woody debris that is round, nearly round, or oval in cross-section. If possible, measure woody debris as circular pieces. Diameters should be taken perpendicular to the bole at the point where its centerline intersects the transect.

1. Woody debris diameter is measured using calipers or diameter tape.

2. If the diameter cannot be measured, estimate it (e.g., if woody debris is suspended and not measurable, visually estimate the diameter at the intersect point).

3. If the cross-section is oval rather than circular, estimate an "equivalent diameter" that will more accurately suggest the cross-section area. If the cross-section is hard to express as a circle (or equivalent as a circle), refer to the procedures for measuring odd-shaped woody debris.

4. If a log has split open but is still partially held together, record the equivalent diameter as if the piece were whole, re-assembling the piece as necessary.

5. If a stem has shattered into several distinct unconnected pieces, record each piece, according to its size class (LCWD, MCWD, SWD), where its centerline intersects the transect.

6. If the woody debris is hollow, estimate the diameter equivalent to the remaining wood.

Coarse Woody Debris – Odd-Shaped Pieces and Accumulations (LCWD and MCWD)

The term "odd-shaped" refers to pieces of woody debris that are not round or oval in cross-section. The term "accumulation" refers to piles or heavy accumulations of woody debris that may be encountered along the transect where it would be impractical, time consuming, and tedious to measure each piece individually (e.g., felled and piled timber, logging debris or slash piles, and broken-off tree crowns containing many branches).

Odd-shaped pieces and accumulations are considered rectangular in cross-section; therefore, instead of a diameter measurement, the length and depth of the rectangle (representing a cross-sectional area of the piece along the plane formed by the line transect) are recorded.

- A different volume compilation formula is used for odd-shaped pieces and accumulations because the measurement is made along the transect line, not at right angles to the centerline of the woody debris.

- It is incorrect to measure the length and depth, average the values, and record this value as a circular cross-section.

- Any woody debris that is not round or oval in cross-section should be recorded in this category.

- Calculate the area transected along the woody debris line. Compare this value to the equivalent areas below to determine the size class for the piece. Equivalent piece sizes for odd-shaped woody debris are:

  LCWD > 706 cm^2

MCWD	> 44 cm^2 and ≤ 706 cm^2
SWD	> 0.08 cm^2 and ≤ 44 cm^2.

Measurements for odd-shaped pieces should be along the transect line where the piece intersects the transect.

- Measure the full horizontal length along the transect of the odd-shaped piece.
- Measure the depth of the odd-shaped piece in several places along the transect.
- Calculate the average depth of the odd-shaped piece from the depth measurements.

Accumulations should be measured along the transect line where the pieces intersect the transect.

- Visually compress the pile to measure the actual cross-sectional area of wood, not the space between the pieces.
- Measure only pieces of woody debris that meet the size criteria.
- Measure the horizontal length of the accumulation along the transect.
- Measure the depth of the accumulation in several places along the transect.
- Calculate the average depth of the accumulation from the depth measurements.
- If the accumulation contains a mix of species, determine the area of the accumulation along the transect. Calculate the *proportion* of the area for each species present in the accumulation. Record lengths and depths for each species that will yield the correct area along the transect for **each** species.

Small Woody Debris

Small woody debris includes wood chunks, bark, cones, branches, roots, and sticks > 1.0 cm in diameter and ≤7.5 cm in diameter (or equivalent cross-section) at the point of transect intersection.

For the NFI, small woody debris has been divided into three diameter classes (equivalent area for odd-shaped pieces is shown in brackets):

- 1.1–3.0 cm (0.8–7 cm^2)
- 3.1–5.0 cm (> 7–20 cm^2)
- 5.1–7.5 cm (> 20–44 cm^2)

The dot tally method has been implemented to speed up measuring of many small pieces. By diameter class, count using a dot tally, the number of pieces of small

woody debris that intersect the transect. A go-no-go gauge is used to determine diameter class (Figure 7.5). Guidelines for situations commonly encountered in the field are listed below:

- If aerial pieces are encountered, only measure the pieces < 2.0 m above ground.
- If branches from a fallen tree are encountered, estimate the number of line intersects for each diameter class and record the tallies for each diameter class.
- If full tree crowns containing many small branches or cones are encountered, these may be partially sampled along the transect. Each situation is individually assessed and a decision to take a subsample of the crown is made before measurements are taken. Partial sampling reduces potential errors and sampling time. For example, an Engelmann spruce is encountered along the transect with numerous pieces that qualify as small woody debris (> 1.0 cm and ≤ 7.5 cm in diameter).
- The entire horizontal length of the line intersect through the tree is measured (e.g., 5 m of the line intercepts the tree).
- A subsample of the number of SWD pieces is actually counted by diameter class (e.g., in 1 m of the transect, 30 Class 1 pieces and 20 Class 2 pieces of SWD were tallied).
- The total number of pieces in 5 m of the line intercept is calculated (e.g., 50 pieces of SWD were counted in 1 m of transect, therefore 5 m of transect would have 250 pieces of SWD; the proportion in each diameter class for SWD is determined: 150 pieces – Class 1, 100 pieces – Class 2, and 0 pieces – Class 3).
- Assess the average decay class of all SWD pieces encountered.

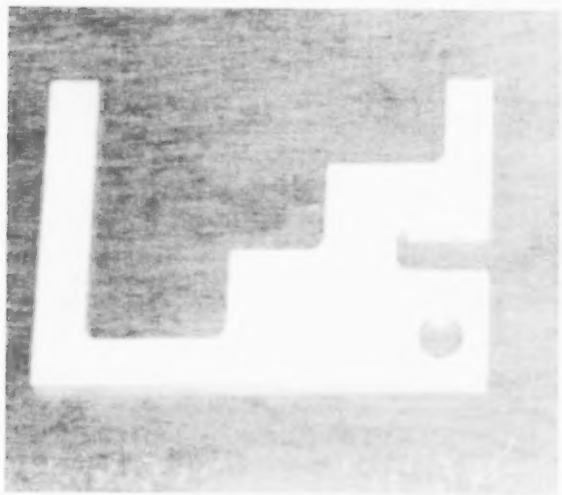


Figure 7.5 **Example of a go-no-go gauge used to determine diameter class of small woody debris along the line transect.**

Completing the Woody Debris Cards (Cards 4a, 4b, 5a, 5b) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first ongoing measurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Transect Azimuth (°):** Record the azimuth for the transect line in degrees (0 to 359°).

6. **Horizontal Transect Length (m):** Record the length of each transect to the nearest 0.1 m that was sampled for:

    a. large coarse woody debris (i.e., 30.0 m),

    b. medium coarse woody debris (i.e., 20.0 m), and

    c. small woody debris (i.e., 10.0 m).

    Record the entire length of each transect in metres (i.e., 30.0 m). Most of the sample transect lengths by jurisdiction are 30.0 m.

    In some cases, a full transect cannot be sampled. When this happens, ensure that horizontal transect length values are adjusted to reflect what could actually be measured. For example, if a cliff was encountered at one end of the transect and only 19 m of a 30-m transect could be safely measured, the following information would be recorded:

    - For large coarse woody debris, record the length measured as 19.0 m.
    - For medium coarse woody debris, record the length measured as 10.0 m.
    - For small woody debris, record the length measured as 5.0 m.
    - For the length of transect, record the nominal or "intended" length of the transect (30.0 m).
    - Record in the comments: Cliff at 19.0 m, remainder of the 30-m transect is inaccessible.

Completing the Woody Debris Field Cards (Cards 4a, 4b): Round Pieces

1. **Piece Number:** Record the number of each piece as it is encountered along the transect.

2. **Genus:** Record the genus of each piece of woody debris using the first four letters of the scientific genus name. Codes for tree species are in Appendix E. For unknown coniferous species, use the code "GENC." For unknown hardwood species, use the code "GENH." If the tree cannot be identified as either a conifer or hardwood, use the code "UNKN."

3. **Species:** Record the species of each piece of woody debris using the first three letters of the scientific species name. For unknown species, use the code "SPP."

4. **Diameter (cm):** Record, to the nearest 0.1 cm, the diameter of each piece of woody debris perpendicular to the bole.

5. **Decay Class:** Observe the whole piece of woody debris and determine the overall decay class. Pieces that are physically attached (lengthwise) are considered to be one piece. Record the decay class code for the whole piece according to the decay class definitions in Table 7.1. The emphasis is on the wood texture. Other criteria, such as portion on the ground, twigs, bark, shape, and invading roots, are guidelines to the wood texture.

Table 7.1 **Woody debris and stump decay class descriptions for NFI reporting.**

	Decay class				
	1	2	3	4	5
Wood texture	intact, hard	intact, hard to partly decaying	hard, large pieces, partly decaying	small, blocky pieces	many small pieces, soft portions
Portion on ground	elevated on support points	elevated but sagging slightly	sagging near ground, or broken	all of log on ground, sinking	all of log on ground, partly sunken
Twigs < 3 cm (if originally present)	twigs present	no twigs	no twigs	no twigs	no twigs
Bark	bark intact	intact or partly missing	trace bark	no bark	no bark
Shape	round	round	round	round to oval	oval
Invading roots	none	none	in sapwood	in heartwood	in heartwood

6. **Tilt Angle (°):** Measure and record, in degrees, the tilt angle between the central axis of the woody debris and the horizontal plane at the intersect point. This can generally be achieved by placing a clinometer on the top surface of the woody debris at the point of the intersect and recording the angle of the piece in degrees. Measure the angle the woody debris makes with the horizontal, regardless of the slope of the ground.

Completing the Woody Debris Field Cards (Cards 4a and 5a): Accumulation and/or Odd-shaped Pieces

1. **Piece Number:** Record the number of each piece as it is encountered along the transect.

2. **Genus:** Record the genus of each piece of woody debris using the first four letters of the scientific genus name. Codes for tree species are in Appendix E. For unknown coniferous species, use the code "GENC". For unknown hardwood species, use the code "GENH". If the tree cannot be identified as either a conifer or hardwood, use the code "UNKN".

3. **Species:** Record the species of each piece of woody debris using the first three letters of the scientific species name. For unknown species, use the code "SPP".

4. **Horizontal Length (cm):** Record, to the nearest centimetre, the length along the transect of each odd-shaped piece of woody debris. For accumulations, measure the distance along the transect to the nearest centimetre.

5. **Vertical Depth (cm):** Record, to the nearest centimetre, the average depth along the transect of the odd-shaped piece of woody debris. For accumulations, record the average depth, remembering to visually compress the pile and not measure spaces between pieces.

   Note on accumulations of mixed species: This value may need to be adjusted to accurately record the proportion of each species.

6. **Decay Class:** Observe the whole piece of woody debris and determine the overall decay class. Record the decay class code for the whole piece according to the decay class definitions in Table 7.1. The emphasis is on the wood texture. Other criteria, such as portion on the ground, twigs, bark, shape, and invading roots, are guidelines to the wood texture.

   Note on accumulations of mixed species: This value will be the average decay class for all of the pieces of each species in the accumulation.

7. **Accumulation/Odd-Shaped:** For each occurrence, record the appropriate one-letter code:

A	Accumulation
O	Odd-shaped piece

Completing the Small Woody Debris Field Cards (Cards 4b and 5b): Small Woody Debris

1. **Tally of Pieces by Diameter Class:** Enter the total number of tallies per diameter class.

2. **Average Decay Class:** Assign an average decay class for all pieces of SWD using the decay class descriptions in Table 7.1. The five decay classes are based primarily upon wood texture, and secondarily on other wood characteristics. Decay classes are based on the majority condition of the entire piece.

7.6 Ongoing Measurement of Woody Debris

Measurement of woody debris at each successive visit will require the re-establishment of the woody debris transects along the same bearing used in the initial establishment.

- Establish the transects along the previous azimuth used in the initial establishment.
- Record the header information and lengths of transect sampled for the classes of woody debris.
- Measure all pieces of woody debris as encountered along the transect, recording the species, diameter (or length and depth of odd-shaped pieces and accumulations), decay class, and tilt angle for round pieces.

After completion of the ongoing measurement, it would be appropriate to refer to the previous measurement data to confirm any data anomalies. In the comments section of the card, document any significant changes from the previous measurement.

8.0 Surface Substrate Measurements

8.1 Introduction

Surface substrate information is collected to support NFI requirements for the measurement of total ecosystem carbon stocks. In some forest types, surface organic materials may account for 20–40% of the total ecosystem carbon and may change significantly 10–20 years following a disturbance (e.g., post-harvest). To accurately estimate carbon values, the variation in surface substrate type and the average depths of organic matter and buried wood need to be measured in the field. Surface substrate data will be used in analysis for reports on criteria, and indicators of sustainable forest management, biodiversity, forest health, and climate change.

8.2 Objectives

- To estimate the depth of the organic and buried wood layers to calculate carbon.
- To estimate the variability of surface organic depths and the cover of surface organics.

8.3 Definitions

Deep organic substrates: Organic matter > 40 cm in depth.

Shallow organic substrates: Organic matter ≤ 40 cm in depth.

Surface substrate: For the NFI, surface substrate is defined as the surface or medium available for plant growth or attachment.

8.4 General Procedures

1. Use the two 30-m line transects used for the woody debris measurements established along their pre-determined azimuths.
2. In shallow organic substrates, assess and measure surface substrate every 2 m along each transect.
3. In deep organic substrates, assess and measure surface substrate every 4 m along each transect up to 500 cm deep.
4. Determine surface substrate types.
5. If encountered, measure depth of organic and buried wood substrates.

Field Cards for Surface Substrate

Surface Substrate Tally - Transect 1 (6a) (Appendix B, Diagram 9)
Field card for the random Transect 1: surface substrate type, surface substrate depth (for organic and buried wood only), impenetrable layer type.

Surface Substrate Tally - Transect 2 (6b) (Appendix B, Diagram 10)
Field card for the random Transect 2: surface substrate type, surface substrate depth (for organic and buried wood only), impenetrable layer type.

8.5 Detailed Procedures

Establishing and Assessing the Transect Conditions

Surface substrate is measured along the two horizontal, 30-m line transects used for woody debris. Normally, the full length of the transect will be sampled. However, because the transects are based on a random bearing, unsafe or difficult conditions may be encountered and you may be unable to sample the full length. Possible transect conditions include:

- **Normal conditions:** Sample each transect using the procedures outlined below.
- **Anomalous conditions:** If the line intercepts an anomaly along the transect, such as a stream, pond, avalanche chute, or a rock outcrop, continue to sample the line as long as it is safe to do so. Make a note of this in the comments section of the tally card (see Appendix D: Partially Forested Plots).
- **Mixed organic condition along transects:** Assess the entire survey site for the depth of organic substrates. Measure every 2 m along both transects unless > 75% of the survey site is located in deep organics. If > 75% of the site is covered by deep organics, measure every 4 m along *both* transects.
- **Unsafe conditions:** If the sample line intercepts unsafe conditions, record the length of the line actually sampled in the field. For example, if a cliff was encountered and only 19 m of the transect could be safely measured, record "horizontal length observed 19.0 m out of 30.0 m." Note in the comments section why a portion was not sampled.

Establishing the Sampling Stations along Line Transects

Sampling stations should be placed as follows:

- In shallow organic substrates (≤ 40 cm), sampling should occur every 2 m along the transects, beginning at the farthest ends away from the plot center (Figure 8.1). Distances are located at 30, 28, 26, 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, and 2 m at establishment.
- In deep organic substrates (> 40 cm), sampling should occur every 4 m along the transects. Distances are located at 30, 26, 22, 18, 12, 8, and 4 m at establishment. If necessary, several test samples can be taken in and around the sample site to determine the average depth of the substrate. If most (≥ 75%) of the site has organic depth measurements > 40 cm, then surface substrate should be measured every 4 m along the transects.

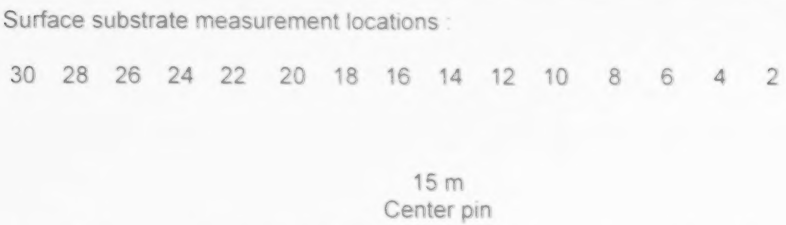


Figure 8.1 **Station setup for surface substrate measurements (sample every other station at deep organic sites).**

Assessing Surface Substrate

Procedure along Transect

1. Assess woody debris along transects **before** assessing surface substrate. Surface substrate measurements are taken after woody debris measurements to avoid disrupting woody debris along the line before it has been assessed.

2. Start at the first station along transect 1. Use the decision key (Figure 8.2) to determine which surface substrate to tally for that station.

3. In shallow organic sites, if the substrate has been identified as organic matter or buried wood (or a combination of the two), measure the thickness of the substrate down to mineral soil. Measurements can be made by exposing the vertical depth of the substrate using a rectangular gardening shovel. This can be done by placing a shovel straight into the ground and pushing forward on the shovel handle. Examine the straight back edge of the exposed substrate. Measure depth to mineral soil.

4. In deep organic sites, if the substrate has been identified as organic matter or buried wood (or a combination of the two), use a soil probe with extensions to measure the thickness of the substrate to an impenetrable layer. Simply press down on the soil probe until it comes into contact with an impenetrable layer or to a maximum depth of 500 cm.

5. On the field card, check the type of impenetrable layer reached.

   Note: The measurement of surface substrate does not require major digging or excavation at each point. After measuring the surface substrate, return the original layers to its original placement or as natural as possible. One should not see the completed sampling location without close inspection.

6. Advance along the transect, repeating the sampling every 2 m until the end of the transect is reached. This procedure will provide a total of 15 sampling stations per transect (based on a 30-m transect). If the site has deep organic soils (> 40 cm in depth) throughout, sampling stations will be located every 4 m along the transect for a total of 7 stations per transect (based on a 30-m transect).

7. Repeat for Transect 2.

8. Surface substrate sampling is most easily performed with two people: one person identifies the substrates and measures its attributes, while the other records the information on the data sheets.

Determining Surface Substrate Type

Use Table 8.1 to determine the type of surface substrate encountered at each station. The surface substrate type is evaluated at the point of intersection with the transect. Mark an "X" in the applicable section on the tally sheet. Only one substrate type is selected for each point.

If a live tree or stump, or other unmeasurable obstacle (i.e., large glacial erratic), is located at the survey station, do NOT reposition the sampling station. Make a comment about the unsampled station and continue to the next station along the transect.

Determining Surface Substrate Depth

Where the surface substrate type has been identified as organic matter or buried wood, measure and record the depth to mineral soil. If there is a combination of organic matter and buried wood, measure the combined depth to mineral soil. At deep organic sites, use a soil probe to measure the depth of the organic substrate down to an impenetrable layer or to a maximum depth of 500 cm.

Anomalous conditions

- If the sample point lands on a live tree, stump, or obstacle (such as a large glacial erratic), the sample point should not be moved to avoid biasing the sample. If a station cannot be sampled, the station is not measured. Comments should be made on the tally card about where and why the station was not measured. The total number of stations will reflect that one or more stations were not measured.

- If the station lands on a sound log (decay class 1 or 2), and it is safe to do so, move the log order to access the sampling point. After finishing the measurements, replace the log into its original position.

  If the log is too large to move, **move** the station slightly farther along the transect to access the substrate. The sampling point should be moved just past the obstacle to a position nearest the transect sampling station. Comments should be made on the tally card about the location of the moved station.

- If the sample point along the transect lands in a site such as a squirrel cache (organic) or large anthill (organic or mineral), the surface substrate is classified accordingly and a depth to mineral soil is measured, where applicable.

- If a water table is encountered, measure past the water table to determine the depth.

- The anomalous conditions encountered should be noted in the comments section.

Table 8.1 Surface substrate types and definitions.

Surface substrate	Definition
Organic matter	Surficial accumulations of organic materials include the following: • organic layers ≥ 1 cm thick overlying mineral soil, cobbles, stones, or bedrock (LFH layers) • layers of decaying wood ≤ 10 cm thick • large animal droppings • areas covered by mats of bunchgrasses (mats include L horizons) • combinations of organic matter and buried wood where organic matter makes up most of the combined thickness to mineral soil.
Buried wood	Woody debris > 10 cm thick in decay class 3, 4, or 5, with > 50% of its thickness located **below** the ground surface: • does not include freshly fallen material that has not yet begun to decompose (e.g., decay class 1 and 2 logs). Note that if there is a recently fallen class 1 or class 2 log blocking measurement, move the sample point to just beside the log (see anomalous conditions) • may be covered by mosses, lichens, liverworts, or other plants • includes combinations of organic matter and buried wood where buried wood makes up the majority of the combined thickness to mineral soil.
Decaying wood	Woody debris > 10 cm thick in decay class 3, 4, or 5, with ≥ 50% of its thickness located **above** the ground surface: • does not include freshly fallen material that has not yet begun to decompose (e.g., decay class 1 and 2 logs). Note that if there is a recently fallen class 1 or class 2 log blocking measurement, move the sample point to just beside the log at a point nearest the transect (see anomalous conditions) • may be covered with mosses, lichens, liverworts, or other plants
Bedrock	Bedrock includes exposed consolidated mineral material: • may be covered by mosses, lichens, liverworts, epilithic plants, or an organic layer < 1 cm in thickness.
Rock or cobbles and stones	Rock (cobbles and stones) include exposed unconsolidated rock fragments > 7.5 cm in diameter: • may be covered by mosses, lichens, liverworts, epilithic plants, or an organic layer < 1 cm in thickness • does not include gravels < 7.5 cm in diameter.
Mineral soil	Unconsolidated mineral material of variable texture: • includes small cobbles and gravel < 7.5 cm in diameter • may have a partial cover of mosses, lichens, liverworts, or an organic layer < 1 cm in thickness • often associated with cultivation, tree tip-ups, active erosion or deposition, severe fires, trails, or late snow retention areas • areas of living grass or forb cover where mineral soil is visible between stems are classed as mineral soil, as are exposed Ah or Ae horizons.
Water	Streams or areas of open water in bogs or fens: • does not include "casual", non-permanent water, or water table • the sample point should be recorded to reflect the conditions at the time of sampling. For example, a gravel or sandbar in a stream that is below the high water mark but exposed during the survey would be recorded as mineral soil.

Completing the Surface Substrate Field Cards (Cards 6a and 6b) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Transect Azimuth (°):** Record the azimuth for the transect line in degrees.

6. **Length of Transect Measured (m):** Record, to the nearest 0.1 m, the total length of transect along which surface substrate was actually measured.

Completing the Surface Substrate Field Cards (Cards 6a and 6b) Details

1. **Surface substrate type:** Check the appropriate surface substrate type at each measurement station according to the definitions in Table 8.1 and Substrate Decision Key (Figure 8.2). Under rare circumstances, a tally for a station cannot be completed. No measurements should be put into the columns for the unmeasured station.

2. **Organic depth and buried wood depth:** If the substrate type is identified as buried wood or organic matter, measure the thickness of the substrate down to mineral soil or other impenetrable layer (to a maximum depth of 500 cm).

3. **Depth measured to...:** Check the box that identifies the impenetrable layer to which the depth was measured to (i.e., mineral soil, bedrock, frozen layer, sound wood, other or unknown impenetrable object, or maximum depth).

8.6 Ongoing Measurement Procedures for Surface Substrate

- Review the sampling protocols used in the initial measurements for shallow or deep organics.

- In shallow organic soils, sampling should occur every 2 m along the transects, beginning at the farthest ends away from the plot center (Figure 8.3). Stations for the first ongoing measurement of surface substrate will be located 0.5 m offset from the original locations at 29.5, 27.5, 25.5, 23.5, 21.5, 19.5, 17.5, 15.5, 13.5, 11.5, 9.5, 7.5, 5.5, 3.5, and 1.5 m.

- In deep organic soils, sampling should occur every 4 m along the transects. At the first ongoing measurement, the locations are 0.5 m offset at 29.5, 25.5, 21.5, 17.5, 13.5, 9.5, and 5.5 m.

Surface substrate ongoing measurement locations:

29.5 27.5 25.5 23.5 21.5 19.5 17.5 15.5 13.5 11.5 9.5 7.5 5.5 3.5 1.5

|

15 m

Center pin

Figure 8.2 First ongoing measurement station setup for surface substrate measurements (sample every other station at deep organic sites).

- Stations for the second ongoing measurement of surface substrate will be located 0.5 m offset from the original locations at 28.5, 26.5, 24.5, 22.5, 20.5, 18.5, 16.5, 14.5, 12.5, 10.5, 8.5, 6.5, 4.5, 2.5, and 0.5 m (Figure 8.4).
- In deep organic soils, sampling should occur every 4 m along the transects, in the same design as above.

Surface substrate ongoing measurement locations:

28.5 26.5 24.5 22.5 20.5 18.5 16.5 14.5 12.5 10.5 8.5 6.5 4.5 2.5 0.5

|

15 m

Center pin

Figure 8.3 Second ongoing measurement station setup for surface substrate (sample every other station at deep organic sites).

- Stations for the third ongoing measurement will be at the original locations.

9.0 Ecological Plot

9.1 Introduction

The purpose of the Ecological is to collect accurate information about plant species composition and evaluate change in species presence and cover over time. From this information, the community structure of the sample area can be assessed, biodiversity indices can be estimated, and ecological classification can be applied to the samples.

To do this, each crew will assemble a list of the species at all levels and estimate the cover of each vegetation species as it occurs within NFI ground plots.

9.2 Objectives

- To collect accurate information about plant species composition and abundance in NFI plots.
- To calculate a diversity index from the species count data and relative abundance.

9.3 Definitions

For this inventory, field crews should be given the list of local vegetation species and their official designation (tree, shrub, herb, and bryoid). Field crews are encouraged to take their vegetation lists into the field with them for reference. Plant species are recorded using accepted standard codes, which adhere to the following rules:

Genus: record the genus of each plant using the first four letters of the scientific genus name.

Species: record the species of each plant using the first three letters of the scientific species name.

Variety: record the variety of each plant (if applicable) using the first three letters of the scientific variety name.

Bryoids: For this inventory, bryoids include mosses, liverworts, hornworts, and non-crustose lichens.

Herbs: All herbaceous species, including forbs (including ferns and fern allies), grasses, sedges, and rushes.

Shrubs: For this inventory, shrubs are woody perennial plants, typically shorter than most trees, having multiple stems that branch from the base without a well-defined main stem.

Trees: For this inventory, a tree is a woody plant, usually with a single stem and definite crown that can reach a mature height of 5.0 m somewhere within its natural range.

9.4 General Procedures

1. Establish a 10-m fixed-radius plot and a 5.64-m fixed-radius plot as per the guidelines.

2. In each plot, record genus, species, variety, vegetation layer, and percent cover estimates for all vegetation growing from material in *direct* contact with the ground (i.e., forest floor/soil, rock, woody debris).

Field Card for the Ecological Plots

Tree and Tall Shrub Species Card (7a) (Appendix B, Diagram 11)
Field card for all tree and tall shrub species in the 10.0-m plot: layer, genus, species, variety, percent cover.

Low Shrubs, Herbs, Bryoids, and Tree Seedlings Card (7b) (Appendix B, Diagram 12)
Field card for all low shrub, herb, and bryoid plant species, as well as tree seedlings within the 5.64-m plot: layer, genus, species, variety, percent cover.

9.5 Detailed Procedures

Ecology Plot Establishment

For measurement of vegetation within the tree and tall shrub layers, establish a 10.0-m slope-corrected, fixed-radius plot, centered at ground plot center (Figure 9.1).

For measurement of vegetation within the low shrub, herb, and bryoid layers, establish a 5.64-m slope-corrected fixed-radius plot, centered at ground plot center.

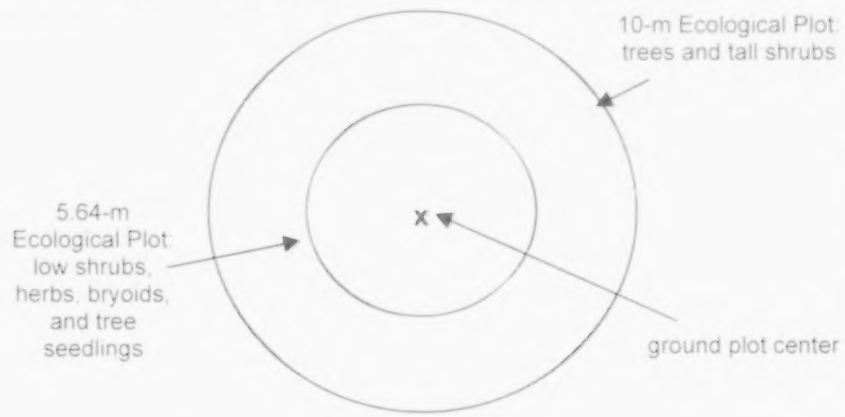


Figure 9.1 **Ecological Plots used for identifying vegetation and estimating cover.**

Vegetation Layers

Within the Ecological Plots, all vegetation species will be listed and grouped by layer. Coverage will be estimated for each species occurring in each layer. For this inventory, vegetation layers are defined as follows:

A Layer (Trees): Any species taller than 10 m in height (Figure 9.2). These are usually tree species. For the Ecological Plots, no subdivision of height within this layer is necessary.

B1 Layer (Tall Shrubs): Includes woody species (tree and shrub) ≥ 2.0 m and ≤ 10 m in height (Figure 9.2).

B2 Layer (Low Shrubs): Includes woody species (tree and shrub) where the entire plant is < 2.0 m in height (Figure 9.2). Tree species ≥ 2 years old.

C Layer (Herbs): Herbaceous species including forbs, ferns, grasses, sedges, rushes, saprophytes, club-mosses, horsetails, and some low woody species.

D Layer: Includes bryoids (mosses, liverworts, foliose, and fruticose lichens) and tree seedlings < 2 years old.

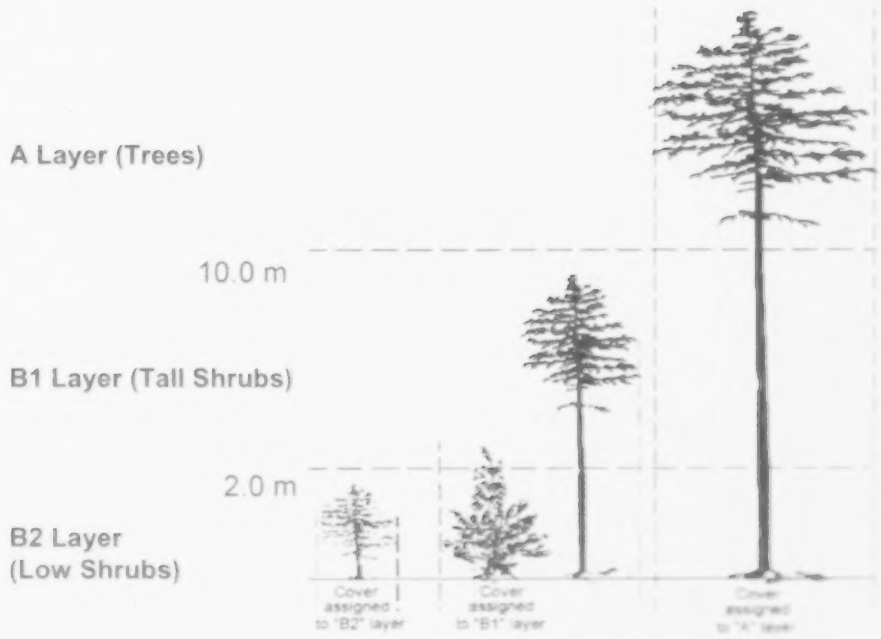


Figure 9.2 NFI tree and shrub layers with vertical projection of crown coverages (BC MOF 2007).

Where to Assess Vegetation

All vegetation growing within or with cover in the Ecological Plots should be documented. Within the 10-m fixed-radius plot, record all plant species in the A and the B1 layers. Within the 5.64-m fixed-radius plot, record all plant species in the B2, C, and D layers.

- All species should be recorded with the exception of epiphytes. For example, bryoid species growing on the sides of trees or on overhanging branches should not be recorded.

- For vegetation species of very low coverage, an exhaustive list is not expected. Given the seasonal variation in flowering and vegetative production, species of very low coverage (< 0.01%) can easily be missed. Concentrate on species having > 0.01% coverage.

Describing Vegetation

1. Identify and record all live plant species within the Ecological Plots.

   - Species codes will consist of the first four letters of the genus, the first three letters of the species, and the first three letters of the variety (if applicable).

   - In some cases, plants have identical seven letter codes. Each jurisdiction is responsible for providing its field crews with master lists of vegetation species to ensure that the correct codes are being used.

2. Maintain a systematic method of recording the species in the plot. The results are much easier to read and compile. One common method is to record species by vegetation layer starting with the uppermost layer, and within each layer by abundance.

3. Crews should ensure that species identification is consistent on timber and ecology field cards. For example, tree or shrub species within the Small Tree and Shrub plot (3.99-m radius) should be listed on at least one of the ecology cards, depending on the layer.

4. Collect samples of any unknown species, bag, and label them for later identification by specialists. Record the item number from the field card on the tagged plant sample as a cross-reference (see section below).

5. Certain plant associations are more difficult to sample (i.e., subalpine, wetlands, riparian edge communities, grasslands, rock outcrops, and disturbed sites with introduced weedy and non-native species). It may be necessary to have these plots sampled by specialists.

Collecting Unknown Species

1. Collect a sample of any species that cannot be identified in the field for which a percentage was recorded. The unknown plant sample should be collected for identification in the lab. If possible, collect the sample from *outside* of the

plot. In addition, take photographs of unknown specimens at several angles to aid in identification.

2. Collect enough of the unknown plant for proper identification:

   a. For trees and shrubs, collect representative samples of flowers, fruits/cones, bark, a branch with leaves (needles) showing branching patterns. Record the height of plants when they are not collected as an intact specimen.

   b. For herb-layer species, collect the entire plant or as much of the plant as feasible, including roots and, in particular, any flowering structures.

   c. For bryoids, collect a sample the size of a "palm-of-the-hand." Try to include sporophytes or lichen apothecia. Do not press.

   d. The following points will ensure good-quality specimens:

      - Use appropriate containers: paper bags, envelopes, plastic bags (allow air in occasionally).
      - Press or process as soon as possible.
      - Keep different genera separated.
      - Keep bryoid samples separated and unpressed to maintain their three-dimensional form.
      - Cross-reference to item number on field card.

   e. Complete a waterproof plant label for each plant sample to be identified (Figure 9.3). For woody and herbaceous species, the label should be affixed to pressed specimens. For bryoid species, the label should be placed in the sample bags or containers. In the comments section of the NFI Vegetation List Field Form, record the Network Label number and probable identification.

      When completing the label, concentrate on microsite conditions directly associated with the plant. Typical microsite habitat information includes:

      - soil or substrate conditions (humus, decaying wood, fibric organic soil, coarse-textured or fine-textured mineral soil, disturbed or recently mixed soil, soil moisture and nutrient conditions, salinity);
      - drainage (seepage track, stream, or pond margin, depressional hollow or shedding mound); and
      - exposure and other physical factors (growing in open exposed or in relatively protected shaded conditions, in an avalanche or a slide track, exposure to periodic or frequent flooding from standing or moving water).

NFI SAMPLE LABEL - UNKNOWN PLANT LABEL	
Network Label: _____	Jurisdiction: _____
Collector: _____	Date: _____
Measurement #: 0 1 2 3 4	Plant #: _____
Probable ID: _____	Plant Ht: _____ cm
Plant Type (circle one)	
Shrub Fern Graminoid Forb Bryophyte Lichen	
Neighboring plants/Community type	
Microsite habitat conditions and plant descriptive notes	
Correct Name:	
Identified By:	

Figure 9.3 Example of unknown vegetation sample label.

f. Record only the most applicable microsite conditions, such as associated with an exposed seepage draw in saturated nutrient-poor organic soil, growing in steep well-drained mor humus beneath a large canopy gap, on disturbed sandy mineral soil associated with overturned tree roots, in a rocky south-aspect grassy patch with coarse, well-drained dark soil.

g. In the descriptive notes, include diagnostic characteristics that may not be obvious from a casual look such as:

- distribution and abundance (solitary individuals in a scattered pattern; common and growing in small clumps; several large clumps within the plot; continuous coverage);
- leaves (leaves feel slightly sticky; fresh leaves have a cucumber scent when crushed; blades have an undulating margin); and
- associated species (with skunk cabbage and lady fern; within clumps of *Cladonia* spp., in patches with *Veratrum*, *Fauria*, and *Sphagnum*).

h. Keep documentation on the labels as concise and applicable as possible. Do not allow labels to become separated from their relevant plant samples.

Completing the Tree and Tall Shrub Species Card (7a)

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Plot Type:** Enter a three-character plot type code. For example, if you have used a 10-m and a 5.67-m radius plot for your survey, the large plot may be coded as EC1 and the small plot as EC2.

   - **EC 1to EC9** = circular Ecological Plot(s)
   - **ES1 to ES9** = square Ecological Plot(s)
   - **ET1 to ET9** = ecological transect(s)

6. **Nominal Plot Size (ha):** Record the intended areas of the Tree and Tall Shrub Ecological Plot to the nearest 0.0001 ha. A circular Tree and Tall Shrub Ecological Plot with a radius of 10.0 m will have an area of 0.0314 ha.

7. **Measured Plot Size (ha):** Record the measured area of the Tree and Tall Shrub Ecological Plot to the nearest 0.0001 ha. A circular Tree and Tall Shrub Ecological Plot with a radius of 10.0 m will have an area of 0.0314 ha. If less than a full plot was measured due to safety or other factors, calculate and record the actual area sampled. Provide comments as to why a full plot was not completed. In most samples, the nominal and measured plot sizes will be the same.

8. **Vegetation Layer:** Within the 10-m plot, record the vegetation layer where each individual live species occurs (A or B1), using the assigned provincial/territorial codes. Species may occur in more than one layer (i.e., *Picea mariana*, black spruce, may occur in the D layer, B2 layer, B1 layer, and A layer). For each layer, a new line will be used. Record ONLY the tall shrub and tree layers on this card.

Table 9.1 Vegetation layer codes for the Tree and Tall Shrub Ecological Plot.

Layer	Description
A	**Trees:** includes all trees and shrubs taller than 10 m.
B1	**Tall shrubs:** includes all shrubs and trees 2.0–10 m in height. In some ecosystems, the canopy of mature trees may be < 10 m tall and should therefore be recorded in the B1 layer.

9. **Genus:** By vegetation layer, record all A and B1 layer plant species in the 10-m plot using the first four letters of the scientific genus name.

10. **Species:** Record the first three letters of the scientific species name that corresponds to each genus name. For species with similar seven letter codes confirm the code from provincial master list. **Field crews should confirm tree species identification with the timber sampling crew to ensure the same species are being recorded.**

11. **Variety:** If applicable, record the variety of each plant using the first three letters of the scientific variety name. Field may be left blank.

12. **Species Coverage (%):** This field is for recording the percent of the ground surface covered by the vertical projection of the crown of the plant onto the ground surface (Figure 9.2).

    - Assess area cover to the nearest 0.001% (Table 9.2).
    - When estimating percent cover, do not bias estimates because of crown density. Except for distinct holes in the crown, the area within the perimeter of the crown is assumed to be fully covered. Estimates will vary somewhat between individuals; however; the relative cover values are required to provide information on species abundance, and attach to photo data.
    - Cover values for individual plant species in each vegetation layer will be estimated. Within each layer, overlapping crowns are not additive for the same species; consequently, a given species cannot have coverage > 100% in a single layer.
    - Assessing cover by layer will sometimes result in total coverages exceeding 100%.
    - Be sure to assess species coverage carefully on sloped surfaces. Cover is the vertical projection of the crown onto the ground, so the cover is converted to horizontal distance.
    - If a portion of the plot is within a non-forested area, estimate the vegetation cover for the area that is contained within the forested site (see Appendix D: Partially Forested Plots). Include accurate drawings and comments on the Vegetation and Cluster Cards.

Table 9.2 **Conversion factors from percent coverage to horizontal area for a 10-m radius plot.**

Percent coverage	10-m radius plot (314 m^2)
Horizontal surface area	314 m^2
25% coverage	¼ of the plot OR 78.5 m^2
1% coverage	1.8 × 1.8 m OR 3.1 m^2
0.1% coverage	~ 55 × 55 cm OR 0.3 m^2
0.01%	~18 × 18 cm OR 314 cm^2
0.001%	~6 × 6 cm OR 31.4 cm^2

Completing the Low Shrub, Herb, Bryoid, and Tree Seedling Species Card (Card 7b)

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

13. **Plot Type:** Enter a three-character plot type code. For example, if you have used a 10-m and 5.64-m radius plot for your survey, the large plot may be coded as EC1 and the small plot EC2.

    - **EC1 to EC9** = circular Ecological Plot(s)
    - **ES1 to ES9** = square Ecological Plot(s)
    - **ET1 to ET9** = ecological transect(s)

5. **Nominal Plot Size (ha):** Record the intended areas of the Low Shrub, Herb, Bryoid, and Tree Seedling Ecological Plot to the nearest 0.0001 ha. A circular Low Shrub, Herb, Bryoid, and Tree Seedling Ecological Plot with a radius of 5.64 m will have an area of 0.0100 ha.

6. **Measured Plot Size (ha):** Record the measured area of the Low Shrub, Herb, Bryoid, and Tree Seedling Ecological Plot to the nearest 0.0001 ha. A circular Low Shrub, Herb, Bryoid, and Tree Seedling Ecological Plot with a radius of 5.64 m will have an area of 0.0100 ha. If less than a full plot was measured due to safety or other factors, calculate and record the actual area sampled. Provide comments as to why a full plot was not completed. In the majority of samples, the nominal and measured plot sizes will be the same.

7. **Vegetation Layer:** Within the 5.64-m plot, record the vegetation layer where each individual live species occurs (B2, C, or D), using the assigned provincial/territorial codes. Species may occur in more than one layer (i.e., *Picea mariana*, black spruce, may occur in the B2 layer and the D layer). For each layer, a new line will be used. Vegetation layer codes are contained in Table 9.3.

Table 9.3 Vegetation layer codes for Low Shrub, Herb, Bryoid, and Tree Seedling Ecological Plot.

Layer	Description
B2	**Low shrubs:** consists, with minor exceptions, of shrubs and established tree regeneration < 2.0 m tall and ≥ 2 years old.
C	**Herbs:** includes forbs, ferns, graminoids, saprophytes, club-mosses, horsetails, and some low woody species. These species will be included in the accepted NFI species lists.
D	**Bryoids and seedlings:** includes mosses, liverworts, hornworts, non-crustose lichens, and tree seedlings < 2 years old.

8. **Genus:** By vegetation layer, record all B2, C, and D layer plant species in the 5.64-m plot using the first four letters of the scientific genus name.

9. **Species:** Record the first three letters of the scientific species name that corresponds to each genus name. For species with similar seven letter codes, confirm the code from provincial master list.

10. **Variety:** If applicable, record the variety of each plant using the first three letters of the scientific variety name. Field may be left blank.

11. **Species Coverage (%):** This field is for recording the percent of the ground surface covered by the vertical projection of the crown of the plant onto the ground surface.

    - Assess area cover to the nearest 0.001% (Table 9.4).

Table 9.4 Conversion factors from percent coverage to horizontal area for a 5.64-m radius plot.

Percent coverage	5.64-m radius plot (100 m^2)
Horizontal surface area	100 m^2
25% coverage	¼ of the plot OR 25.0 m^2
1% coverage	1.0 × 1.0 m OR 1 m^2
0.1% coverage	~ 33 × 33 cm OR 0.1 m^2
0.01%	10 × 10 cm OR 100 cm^2
0.001%	~3 × 3 cm OR 10 cm^2

- Cover is estimated as for trees and tall shrubs, estimating the area within the perimeter of the crown of the plant or plants. Estimates will vary somewhat among individuals; however, the relative cover values are required to provide information on species abundance, and attach to photo data. Small coverages such as 0.001 may be used for documenting a single occurrence, such as an orchid (i.e., Coralroot).

- Cover values for individual plant species in each vegetation layer will be estimated. Within each layer, overlapping crowns are not additive for the same species; consequently, a given species cannot have coverage > 100% in a single layer.

- Assessing cover by layer will sometimes result in total coverages > 100%.

- Be sure to assess species coverage carefully on sloped surfaces. Cover is the vertical projection of the crown onto the ground, so the cover is converted to horizontal distance.

- If a portion of the plot is within a non-forested area, estimate the vegetation cover for the area that is contained within the forested site (see Appendix D: Partially Forested Plots). Include accurate drawings and comments on the Vegetation and Cluster Cards.

9.6 Ongoing Measurement Procedures of the Ecological plot

- Establish the 5.64- and 10.0-m fixed-radius plots using the same procedures used in establishment.

- In each plot, record plant species and their cover values by vegetation layer.

10.0 Soil Attributes

10.1 Introduction

The soil resource is a primary component of all terrestrial ecosystems, and any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and hydrology of forest ecosystems (USDA 2002). The objective of the NFI soils program is to measure total ecosystem carbon stocks (TECS) of Canada's forest. The method for determining TECS involves analysis of both the physical and chemical properties of the soils. Soil attributes will be measured at a soil pit in each NFI ground plot. The physical properties of the soils will be described according to the Canadian System of Soil Classification (CSSC) (Soil Classification Working Group 1998). This information, together with the chemical information from the soil and forest floor samples collected in the microplots, will be used to measure total ecosystem carbon stocks of Canada's forests.

10.2 Objectives

- To describe soil characteristics based on the Canadian System of Soil Classification CSSC (Soil Classification Working Group 1998).
- To collect the data that can contribute to the assessment of:
    - availability of nutrients and water to plants (soil structure and texture)
    - carbon sequestration.

10.3 Definitions

Deep organic soil: Organic matter > 40 cm in depth.

Forest floor: Organic material overlying the mineral soil, consisting of the litter, fibric, and humus horizons.

Mineral soil: A soil consisting predominantly of inorganic material (e.g., sands, silts, and clays). Mineral material contains ≤ 17% organic carbon (about ≤ 30% organic matter) by weight. They are commonly found underneath organic materials. The type and amount of mineral material depend on the source of the material, route of deposition, meso/microclimate, and mineralogy.

Organic soil: A soil containing a high proportion of organic matter. They contain > 17% organic carbon (about ≥ 30% organic material) by weight. These soils are often common in wetland areas such as bogs, marshes, and swamps, or found on top of restrictive layers such as permafrost. Organic soils are soils with > 60 cm of organic material (if surfaces horizons are Of), or > 40 cm of organic material (if surface horizons are Om or Oh), or > 10 cm if they overlie rock (Soil Classification Working Group 1998).

Peat: An accumulation of partially decomposed plant material deposited under saturated soil conditions.

10.4 General Procedures

1. Establish a soil pit to a minimum depth of 60 cm for mineral sites or a minimum depth of 100 cm for deep organic sites.

2. Describe and measure soil characteristics and features within the soil pit.

Field Cards for Soils

Soil Pit (8) (Appendix B, Diagram 13)
Field card for soil pit: CSSC soil classification, profile depth, soil drainage, moisture class, parent material, humus form, soil features and depth, horizons, horizon depths, horizon thickness, soil texture, soil color, and percent gravel, cobble, and stones.

10.5 Detailed Procedures

Soil Pit Excavation

Location of Soil Pit

The soil pit should be established in a representative location outside of the Large Tree Plot (11.28-m radius) but within 25 m of the plot center. To assist in determining the best representative location for the soil pit, the surface substrate transects should be completed first. Information obtained from completing these transects will indicate the local soil conditions. With this information, a site *outside* the Large Tree Plot that represents the overall conditions *inside* the plot can be selected. For example, if the surface substrate stations on the transects indicate that the site is mostly organic soil, approximately 40 cm deep, over bedrock, this information can be used to choose a location that has a deep organic layer over bedrock. Do not look for a site that may have organic soils 60–80 cm deep, as this would no longer be representative of the plot.

Soil Pit Excavation

In mineral soils, soil pits are normally ≥ 60 cm deep, unless bedrock or a water table is encountered before reaching this depth (depth starting at surface of the mineral soil). The soil pit in organic soils should be excavated to a minimum depth of 100 cm when possible. In general, a pit is dug to the maximum depth permitted by conditions. The actual depth necessary to determine the moisture regime and drainage class depends on the characteristics of the soil profile. If necessary, use an auger to probe deeper. If it is impossible to reach the C horizon because of boulders, bedrock, cemented layers, water, or ice, record this in the comments section of the Soil Pit Card (Card 8).

- Initially, remove the forest floor layer and set aside. This will be replaced after the soil pit has been evaluated and refilled.

- Excavated soil should be placed on a tarp perpendicular to the pit face to keep the site clean, minimize evidence of disturbance, and make it easier to replace the excavated soil back into the pit once sampling is completed.

- After digging the soil pit, clean one wall of the pit for horizon identification. Position the pit so that the side being evaluated is in uniform lighting

conditions with the brightest sunlight. The side being evaluated (the pit face) should also represent the variation in horizon depths. Ensure that this side is kept in good condition (i.e., do not step on this side of the pit when digging).

- Once the NFI Soil Pit Field Card is completed, return the pit to as natural a state as possible to minimize the impact to the site. Replace any coarse fragments, coarse woody debris, or roots in the pit, and fill in the pit with the excavated soil. Replace the forest floor and tamp down.

Completing the Soil Pit Card (8) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Pit Number:** Record the soil pit number from which soil attributes were measured (Table 10.1). This is usually large pit (LP0). If an additional soil pit was excavated for soil attribute measurement, record the appropriate code.

Table 10.1 Pit number codes.

Code	Soil pit where soil attributes were assessed
LP0	Large (representative) soil pit
PT1	Other location 1
PT2	Other location 2
PT3	Other location 3
PT4	Other location 4

Completing the Soil Pit Card (8) General Soil Information

1. **CSSC Soil Classification:** Enter the CSSC classification for the profile, including the Order, Great Group, and Subgroup (up to nine characters long) referring to the Canadian System of Soil Classification (Soil Classification Working Group 1998) for reporting instructions and codes. For example, enter code GLCU.HR for Gleyed Cumulic Humic Regosol. Another example would be GLG.SO for Gleyed Gray Solod. The profile should be classified to the Subgroup level, if possible but to the Order level (minimum).

2. **Profile Depth (cm):** Enter the total profile depth (in centimetres) from which soil attributes were determined. The soil pit should be measured to a minimum depth of 60 cm when possible (depth starting at surface of the mineral soil) in mineral soils and to a total depth of 100 cm in organic soils.

3. **Moisture Class:** Enter the one-digit code that best describes the moisture class of the soil using the descriptions in Table 10.2.

Table 10.2 Soil moisture class codes.

Soil moisture code	Soil moisture class	Description
1	Xeric	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation. The primary water source is precipitation.
2	Mesic	Water is removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short, period of the year. Available soil moisture reflects climatic inputs. The primary water source is precipitation in moderate to fine-textured soils and limited seepage in coarse-textured soils.
3	Hygric	Water is removed so slowly that the water table is at or above the soil all year; gleyed mineral or organic soils. The primary water source is a permanent water table.

4. **Soil Drainage Class:** Enter the one-digit code from Table 10.3 that best describes the drainage conditions in the plot (definitions from Agriculture Canada Expert Committee on Soil Surveys 1983).

Table 10.3 Soil drainage class codes.

Soil drainage code	Soil drainage class	Description
1	Very rapidly	Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low available water storage capacity (usually < 2.5 cm) within the control section and are usually coarse textured, or shallow, or both. Water source is precipitation.
2	Rapidly	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low available water storage capacity (2.5–4 cm) within the control section, and are usually coarse textured, or shallow, or both. Water source is precipitation.
3	Well	Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Soils have intermediate available water storage capacity (4–5 cm) within the control section, and are generally intermediate in texture and depth. Water source is precipitation. On slopes, subsurface flow may occur for short durations but additions are equaled by losses.
4	Moderately well	Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination within the control section and is usually medium to fine textured. Precipitation is the dominant water source in medium- to fine-textured soils; precipitation and significant additions by subsurface flow are necessary in coarse-textured soils.
5	Imperfectly	Water is removed from the soil sufficiently slowly in relation, to supply to keep the soil wet for a significant part of the growing season. Excess water moved slowly downward if precipitation is the major supply. If subsurface water or groundwater, or both, is the main source, the flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is main source if available water storage capacity is high; contribution by subsurface flow or groundwater flow, or both, increases as available water storage capacity decreases. Soils have a wide range in available water supply, texture, and depth, and are gleyed phases of well-drained subgroups.
6	Poorly	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or groundwater flow, or both, in addition to precipitation are the main water sources; there may also be a perched water table, with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are gleyed subgroups, Gleysols, and Organic soils.
7	Very poorly	Water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Excess water is present in the soil for the greater part of the time. Groundwater flow and subsurface flow are the major water sources. Precipitation is less important except where there is a perched water table with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are either Gleysolic or Organic.

5. **Parent Material Mode of Deposition:** Landforms are described on the basis of genetic deposition. Enter the applicable soil parent material mode of deposition code based on Table 10.4 (codes and descriptions based on Soil Classification Working Group 1998). In some cases, one type of parent

material may overlay another (i.e., fluvial over morainal). Record the *dominant* parent material and include notes in the comments section of the field card.

Table 10.4Codes for soil parent material mode of deposition.

Soil parent material mode of deposition code	Soil parent material mode of deposition	Description
A	Anthropogenic	• artificial or human-modified material • includes landfills, road fill, and mine spoils
C	Colluvial	• deposits as a direct result of gravity (talus, landslide deposits) • on steep terrain, below rock bluffs • coarse fragments, angular, same rock type as bedrock • coarse fragments > 35%, loosely packed, porous • landslide and slope failure deposits
E	Eolian	• materials deposited by wind action
F	Fluvial	• river deposits
L	Lacustrine	• lake sediments; includes wave deposits
M	Morainal	• material deposited directly by glaciers
S	Saprolite	• rock containing a high proportion of residual silts and clays formed by alteration, chiefly by chemical weathering
V	Volcanic	• unconsolidated pyroclastic material
W	Marine	• marine sediments; includes wave deposits
UU	Unspecified Unconsolidated	• a layered sequence of more than three types of genetic material
R	Consolidated: Bedrock	• outcrops/rocks covered by < 10 cm of soil
I	Ice	• permanent snow, glaciers, and icefields
B	Organic: Bog	• sphagnum or forest peat material
FE	Organic: Fen	• sedge peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed in a eutrophic environment due to the close association of the material with mineral-rich waters
SW	Organic: Swamp	• a peat-covered or peat-filled area with the water table at or above the peat surface. The dominant peat materials are shallow to deep, mesic to humic forest and fen peat formed in a eutrophic environment resulting from strong water movement from the margins or other mineral sources
UO	Organic: Unspecified Organic Genetic Material	• unspecified organic genetic material

6. **Humus Form:** Humus form represents the form of the organic and organic-enriched mineral horizons at the soil surface. Humus form must be reported to at least the Order level (minimum). Enter a one- or two-character humus form code from Table 10.5. If there is no humus, enter NA onto the field card.

Table 10.5 Humus form codes.

Order	Order code	Group	Group code
Mull	L	Compact	LV
		Fine	LF
		Medium	LM
		Coarse	LC
Moder	D	Mull-like	DM
		Typical	DT
		Raw	DR
Mor	R	Fibrimor	RF
		HumiFibrimor	RH
		FibriHumimor	RM
		Humimor	RI
Peaty Mor	P	Humic	PH
		Mesic	PM
		Fibric	PF
Anmoor			AM
Not applicable	NA		

Completing the Soil Pit Card (8) Soil Pit Attributes

1. **Horizon Number:** Consecutively number each horizon occurring in the soil pit starting with the uppermost horizon (usually litter) and working downwards.

2. **Horizon Designation:** For each horizon occurring in the soil pit, record the horizon designation according to CSSC conventions. Examples of mineral soil horizon descriptions (OCSRE 1993) and organic horizon descriptions are provided in Tables 10.6 and 10.7. For a full description, please refer to the CSSC manual (Soil Classification Working Group 1998).

Table 10.6 Examples of organic soil horizon descriptions.

Horizon	Description
L	**Litter:** organic horizon characterized by an accumulation of organic matter derived mainly from leaves, twigs, and woody materials in which original structures are easily discernible.
F	**Fibric:** organic horizon characterized by an accumulation of partly decomposed organic matter derived mainly from leaves, twigs, and woody materials. Some of the original structures are difficult to recognize.
H	**Humus:** organic horizon that is characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. It is frequently intermixed with mineral grains, especially near the junction with the mineral horizon.
Of	**Fibric Horizon:** the least decomposed organic material, containing large amounts of well-preserved fibre that can be identified as to plant species origin. They contain ≥ 40% of rubbed fibre by volume. 1–4 von Post scale of decomposition.
Om	**Mesic Horizon:** organic materials at an intermediate stage of decomposition. They contain 10–40% rubbed fibre by volume. 5–6 von Post scale of decomposition.
Oh	**Humic Horizon:** the most highly decomposed organic material, with few recognizable plant remains. They contain < 10% rubbed fibre by volume. 7–10 von Post scale of decomposition.

Table 10.7 Examples of mineral soil horizon descriptions.

Horizon	Description
Ah Ap	Dark colored, mineral surface horizon, enriched with organic matter _p: human modified (e.g., ploughed layer)
Ae	Light colored near surface horizon. Leached horizon with loss of iron, aluminium, organic matter or clay
AB	A transition horizon from A to B
Bt	Brownish, subsurface horizon enriched with clay that has been moved from the Ae horizon
Btgj	A Bt horizon containing distinct mottles but no gray gley colors. The suffix "gj" is also applied to other horizons containing distinct mottles but no gray gley colors (e.g., Bmgj, Ckgj)
Bm	Brownish subsurface horizon with only slight addition of iron, aluminium, or clay
Bf, Bhf	Reddish brown subsurface horizon with significant accumulation of iron, aluminium, and/or clay
Bg	Horizons with gray gley colors or prominent mottling or both. The suffix "g" is also applied to other horizons with these characteristics
BC	A transition horizon from B to C
C	Relatively unweathered material from which the soil profile has developed
Ck	A C horizon containing calcium and/or magnesium carbonates that will effervesce with diluted HCl (10%)
IIBt*	A Bt horizon that has developed in materials which are significantly different in texture (mode of deposition) from the horizons above

* Roman numerals that precede the horizon designation indicate a significant change in texture (mode of deposition) within the profile (e.g., where silt loam occurs over coarse sand, the horizon(s) of coarse sand are preceded by II).

3. **Depth to Upper Horizon Boundary (cm):** For each horizon occurring in the soil pit, record the distance between "zero depth" and the top of the horizon boundary, to the nearest 0.1 cm.

    - For organic material over mineral soils (i.e., LFH layers), the depth is measured upward from the "zero depth". If a 1-cm H horizon is over an Ae horizon, the depth for the H horizon would be recorded as 1.0 cm (Table 10.8).

Table 10.8 Example of recording horizons attributes in mineral soils.

Horizon	Horizon upper depth (cm)	Horizon thickness (cm)
L	10.0	8.0
F	2.0	1.0
H	1.0	1.0
0 line		
Ae	0.0	2.0
Bf	2.0	45.0
C	47.0	14.0

    - For mineral soils, "zero depth" is mineral soil surface (boundary between forest floor organic material and mineral soil). Therefore, the top of the first mineral layer (i.e., an Ae layer) would be 0.0 cm. The top of the next layer (i.e., a B horizon) would be measured down from the "zero depth" (Table 10.8).

    - For organic soils, "zero depth" is the ground surface. All measurements would be measured downward from the "zero depth" (Table 10.9).

Table 10.9 Example of recording horizons attributes in organic soils.

Horizon	Horizon Upper Depth (cm)	Horizon Thickness (cm)
0 line		
Of	0.0	5.0
Om	5.0	23.0
Oh	28.0	–1

4. **Horizon Thickness (cm):** Record the average thickness, to the nearest 0.1 cm, of each horizon occurring in the soil pit. If you are unable to determine thickness, such as a horizon that continues below the bottom of the pit, record "–1" (see example in Table 10.9 above).

5. **Soil Color:** For each **mineral** horizon occurring in the soil pit, record the code that describes the color of each horizon in the soil pit based on the descriptions in Table 10.10.

Table 10.10 Soil color codes.

Soil color code	Soil color description
D	Dark, chocolate brown, or black (Munsell color value < 4 when moist)
M	Medium, intermediate color (most commonly encountered)
L	Light, very pale soil (Munsell color value > 6 when moist)
N	Not applicable (not mineral soil)

6. **Soil Texture:** Soil textural classes are determined by estimating the percentage of clay (< 0.002 mm diameter) and sand (0.05 to < 2.0 mm diameter). Using the soil texture triangle and classification rules in CSSC, determine and record the soil texture of each **mineral** soil horizon in the soil pit (Table 10.11). Record "NA" for organic horizons.

Table 10.11 Soil texture codes.

Soil texture code	Soil texture
HC	Heavy clay
C	Clay
SC	Sandy clay
SCL	Sandy clay loam
CL	Clay loam
SI	Silt
SIL	Silt loam
SIC	Silty clay
SICL	Silty clay loam
L	Loam
SL	Sandy loam
LS	Loamy sand
S	Sand
VFS	Very fine sand
FS	Fine sand
MS	Medium sand
CS	Coarse sand
VCS	Very coarse sand
R	Rock
NA	Non-mineral layers

12. **Percent Gravels:** For each mineral horizon occurring in the soil pit, record the percent coarse fragment content, by volume, of gravel (diameter = 7.5 cm or length = 15 cm). This value may have to be estimated from an exposed face in the soil pit. The total of percent gravels, cobbles, and stones should not exceed 100%.

13. **Percent Cobbles:** For each mineral horizon occurring in the soil pit, record the percent coarse fragment content, by volume, of cobbles (diameter = 7.5–25 cm or length = 15–38 cm). This value may have to be estimated from an exposed face in the soil pit.

14. **Percent Stones:** For each mineral horizon occurring in the soil pit, record the percent coarse fragment content, by volume, of stones (diameter > 25 cm or length > 38 cm). This value may have to be estimated from an exposed face in the soil pit.

15. **Soil Feature:** List *all* features noted in the soil pit. Use the codes listed in Table 10.12 for each feature observed.

Table 10.12 Soil features codes.

Soil feature code	Soil feature
W	Water table or seepage
M	Mottles (not applicable in organic soils)
R	Root-restricting pan
B	Bedrock
F	Frozen layer
C	Carbonates
N	Not applicable or no feature

16. **Depth to Soil Feature (cm):** Record the observed depth in centimetres to each soil feature noted, measured from "zero depth" to soil feature. "Zero depth" is mineral soil surface for mineral soils, and ground surface for organic soils.

10.6 Ongoing Measurement Procedures for Soil Pit

The soil pit will not be remeasured unless the information was not collected in the original plot or there has been a major disturbance (i.e., landslide, major flooding, major fire, mechanical damage, soil movement). A major disturbance should be one that is extensive enough to alter the soil and vegetation establishment of the survey site (≥ 25-m radius). If the disturbance only affects a portion of the survey site, the disturbance must have affected a major portion of the plot and/or adjacent area which may influence the plot (i.e., drainage into or out of plot).

If a disturbance has occurred that would result in significantly different measurements and soil horizons than the previous soil pit measurements, re-excavate the original pit, cleaning off a new face to examine the soil features. A new pit may need to be established, using the same criteria as for the original pit. Each pit should be labeled using codes in Table 10.1. Record new measurements on the soil cards, making

comments as appropriate. After completion of the measurement, it would be appropriate to refer to the previous measurement data to confirm any data anomalies.

11.0 Microplots

11.1 Introduction

Microplots are used to determine biomass of trees and shrubs (< 1.3 m in height), herbs, bryoids, and fine woody debris. In addition, samples of the forest floor organics and soil are collected from the microplots and analyzed to determine bulk density, nitrogen, and carbon content. The data from these measurements will be used in analysis for reports on criteria and indicators of sustainable forest management, biodiversity, forest health, and climate change.

11.2 Objectives

- To provide estimates of forage abundance and vegetation biomass.
- To determine soil carbon content.
- To collect data that can contribute to the assessment of:
  1. availability of nutrients to plants
  2. carbon sequestration.

11.3 Definitions

For the sampling in the microplots, the following definitions apply:

Bryoids: Mosses, lichens and liverworts. For the microplot samples, they also include hornworts, slime molds, and mushrooms.

Cryptobiotic Soil: A fragile and complex mix of lichen, moss, liverworts, algae, fungi, and cyanobacteria that colonize the soil surface in semiarid environments.

Deep Organic Soil: Organic matter > 40 cm in depth.

Fibric: Organic horizon characterized by an accumulation of partly decomposed organic matter derived mainly from leaves, twigs, and woody materials. Some of the original structures are difficult to recognize.

Fine Woody Debris: All woody material ≤ 1.0 cm in diameter. This includes twigs, cones, bark, and wood chunks < 1.0 cm in diameter.

Forest Floor: Organic material overlying the mineral soil or bedrock, consisting of the litter, fibric, and humus layers (LFH). Determining the LFH horizon is usually straightforward in most soil conditions based on the color and texture of the soil and resistance of the shovel to penetrate far into the mineral layer. The organic layer is typically dark, coarse, and fibrous (containing rooting systems), whereas the mineral soil is typically lighter in color, and finely particulate.

Herbs: Includes all herbaceous species regardless of height. Includes forbs (including ferns and fern allies) and graminoid (grasses, sedges, and rushes) species.

Humus: Organic horizon that is characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible. It is frequently intermixed with mineral grains, especially near the junction with the mineral horizon.

Litter: Organic horizon characterized by an accumulation of organic matter derived mainly from leaves, twigs, needles, and woody materials in which original structures are easily discernible.

Mineral Soil: A soil consisting predominantly of inorganic material (e.g., sands, silts, and clays). Mineral material contains ≤ 17% organic carbon (about ≤ 30% organic matter) by weight. They are commonly found underneath organic materials. The type and amount of mineral material depends on the source of the material, route of deposition, meso/microclimate, and mineralogy.

Organic Matter: Non-living material derived from living organisms. Includes needles, leaf litter, and partially decomposed organic material.

Organic Soil: A soil containing a high proportion of organic matter. They contain > 17% organic carbon (about ≥ 30% organic material) by weight. These soils are often common in wetland areas such as bogs, marshes, and swamps, or found on top of restrictive layers such as permafrost. Organic soils are soils with > 60 cm of organic material (if surfaces horizons are Of), or > 40 cm of organic material (if surface horizons are Om or Oh), or > 10 cm if they overlie rock (Soil Classification Working Group 1998).

Small Stumps: The woody base of a tree that remains after the rest of the tree has fallen as a result of decay or rotting or having been cut down (Dunster and Dunster 1996). For NFI purposes, small stumps must be self-supporting, vegetatively dead or dead with live suckers, < 1.30 m in length with a top diameter inside bark of < 4 cm.

11.4 General Procedures

1. Establish four 1-m^2 microplots at the ends of the line transects used for woody debris.
2. From each microplot, collect biomass samples of aboveground vegetation from four groups: shrubs, herbs, bryoids, and fine woody debris.
3. At each microplot (mineral sites only), excavate and collect forest floor samples and measure the average depth of each sample collected.
4. In mineral sites, collect seven soil samples from the microplots. Excavate and collect 1.0- to 1.5-L samples of mineral soil at the approximate depths of:
   a. 0–15 cm (collect four samples, one at each microplot),
   b. 15–35 cm (collect two samples, from two selected microplots), and
   c. 35–55 cm (collect one sample, from one selected microplot).
5. Measure the exact volume of each of the mineral soil samples extracted.

6. In deep organic sites, excavate and collect four organic soil samples from one microplot at the approximate depths of:

   a. 0–15 cm,

   b. 15–35 cm,

   c. 35–55 cm, and

   d. 55–75 cm.

Field Cards for Microplots

Microplot Clipping (9a) (Appendix B, Diagram 14)
Field card for recording biomass sampling information: plot size, oven-dry weight of shrubs, herbs, bryoids, and fine woody debris.

Forest Floor and Soil Samples (9b) (Appendix B, Diagrams 15 and 16)
Field card for forest floor and bulk density samples: forest floor depths, forest floor sample horizons, template size, mineral/organic soil (bulk density) sample information.

11.5 Detailed Procedures

Microplot Establishment

Establish four 1-m^2 plots, each with a radius of 0.56 m, at the ends of the line transects (15 m from the plot center) (Figure 11.1). Microplots are numbered 1, 2, 3, and 4, clockwise, from the 0 m end of Transect 1. Microplots should be established as follows:

- Place a marker, such as a stick or metal pin, at 15.00 m from the plot center, along the pre-determined transect bearing. If using a non-circular microplot (1 m^2), the center of the microplot should still be 15 m from plot center.

- Using a measuring tape or cord that has been measured with the radius distance (0.56 m), temporarily mark the edges of the microplot. The microplot radius should be corrected for slope. Flagging may be used to mark the edges. The microplot will extend onto the line transect; be careful to not interfere with woody debris measurements and surface substrate sampling.

Figure 11.1 Four microplots (1 m^2) positioned at the ends of the line transects.

Anomalous Conditions

- Do not reposition microplots to avoid obstacles such as tree trunks or large boulders, as this could bias the biomass samples. If possible, clip vegetation around the obstacle. If the obstacle takes up the whole microplot, it is likely that there would not be any biomass to sample and it would be recorded as zero. If an obstacle is preventing collection of soil or forest floor samples within the area of the microplot, they can be collected just past the obstacle along the same transect bearing. Provide comments about any sampling anomalies in the comments section on field cards.
- If a microplot falls into a hazardous position (i.e., cliffside, raging stream, wasp nest, animal den), do not reposition the microplot, as this could bias the sample. The microplot will be recorded as unavailable. Place comments about unavailable plots into comments section on field cards.
- If a microplot falls into a non-forested or non-measurable site, the microplot would not be measured (see Appendix D: Partially Forested Sites). Note that microplot(s) outside of the forested area were not sampled in the comments sections of the field cards.
- Microplots are corrected for slope. When a microplot is on a steeply sloped site, only the horizontal distance of the 0.56-m plot is to be sampled. Biomass, fine woody debris, and forest floor samples are taken from the 0.56-m plot, which is vertically projected onto the ground.

Biomass Sampling of Shrubs, Herbs, Bryoids, and Fine Woody Debris

In each microplot, vegetation will be clipped and collected for further analysis. The following materials are clipped and separately bagged:

- shrubs and trees < 1.3 m in height
- all herbs
- all bryoids
- fine woody debris
- small stumps.

The material collected will be dried, weighed, and analyzed (see Appendix M). Each microplot should have a minimum of four sample bags for a total of 16 clipped/collected samples for the whole site. If there is abundant vegetation, more than one bag may be needed for a category (i.e., herbs). If one of the microplots has nothing to clip or collect for one of the bags, mark this on the empty bag.

Collecting Shrubs, Herbs, and Bryoids

For each of the four microplots:

1. Determine what vegetation should be clipped:
    - Determine which clipping category (shrub/tree, herb, or bryoid) each plant falls into. If in doubt, refer to a provincial/territorial plant identification manual or official plant list. All vegetation in the microplot will be sorted into bags by clipping category.
    - A plant is considered "in" or "out" of the plot depending on the germination point where the plant enters the soil. Clip herbs or shrubs if the germination point is within the plot. If a plot splits a large clump of grass (where the germination point is not easily determined), then clip the portion within the plot boundaries.
    - A stolon from a stoloniferous plant (such as wild strawberry) rooted within the plot is considered part of the plot. A non-rooted stolon connected to a stolon rooted within the plot is considered "in" the plot. If two plants connected by a stolon are rooted both inside and outside the microplot, clip the stolon at the plot boundary.
    - If the base of the plant is in standing water, clip the material below water line at ground level, if practical. If not practical, clip the material at the water line and record an estimate of the portion remaining in the comments section.
    - If there is large wood or a large boulder in the microplot:
        - Collect shrubs and herbs from all substrates.
        - Collect bryoids from all surfaces on the ground or surfaces that would be considered the forest substrate. This would include rotten wood and rock that are part of the forest floor. Bryoids should not be collected from wood or boulders that have recently fallen into the plot, which may lie above the ground, and are not part of the main growing substrate.

- If bryoids are growing on the sides of material on the forest floor (i.e., side of rock), collect bryoids from all surfaces in the microplot.

2. Clipping vegetation at each microplot:

   - Clip shrubs and trees < 1.3 m in height at ground level and place into a sample bag. Pieces may be cut into convenient-sized portions to facilitate bagging the material.

   - Clip herbs at the base and place into a sample bag.

   - Clip only the live portions of bryoids and place into a sample bag. Dead parts will be considered part of the forest floor and included with that material.

     - Bryoids can be snipped using larger, angled shears or can be pulled out. The living bryoids should be clipped at the base of the green, photosynthetic material. Only the **live** bryoid layer is collected in this sample (the brown part of the bryoid layer is included as part of the forest floor organic sample).

     - If slime molds and mushrooms are encountered, they should be included with the bryoid samples.

   On each bag, record the network label, microplot number, the sample identifier (i.e., shrubs, herbs, or bryoids) and sample number (e.g., "1 of 1" if only one bag of shrubs was collected; "1 of 2" if two bags were filled).

3. Oven-dry samples in a forced-air drying oven at 70°C until a constant weight is obtained (generally, for 72 h but time may vary depending upon the oven and load).

4. Weigh oven-dry samples to the nearest 0.1 g.

   ***Note*:** If oven-drying cannot be initiated within 24 h of collection, air-dry the samples to prevent decomposition. To air-dry, leave sample bags open in a warm, dry room to let excess moisture escape. Carefully rotate the vegetation in the bags to ensure even drying. This process can continue for several days if necessary.

Collecting Small Stumps

For each of the four microplots:

1. Collect all stumps < 1.30 m in height with top diameters inside bark < 4.0 cm using a small handsaw or clippers to sever small stumps at the base.

2. Place small stumps into a paper sample bag(s). Small stumps may be cut into convenient-sized pieces to facilitate bagging.

3. On each bag identify the sample material (i.e., small stumps), record the network label, the number of the microplot it was collected from, and the sample number (e.g., bag "1 of 1", "1 of 2", depending on how many sample bags were used for small stumps at that microplot).

4. Oven-dry samples in a forced-air drying oven at 55°C until a constant weight is obtained (generally for 72 h, but time may vary depending the oven and load).

5. Weigh oven-dry samples to the nearest 0.1 g.

   Note: If oven-drying cannot be initiated within 24 h of collection, air-dry the samples to prevent decomposition. To air-dry, leave sample bags open in a warm, dry room to let excess moisture escape. Carefully rotate the vegetation in the bags to ensure even drying. This process can continue for several days if necessary.

Collecting Fine Woody Debris

For each of the four microplots:

1. Collect all fine woody debris (FWD) above the litter layer and within the microplot boundaries (including twigs, cones, bark, wood chunks, and other debris).

   - A gauge may be used to identify the FWD to collect from the plot (see Figure 7.5, Section 7: Measuring Small Woody Debris).
   - Pieces that extend into the forest floor (i.e., L/F/H layers) will be clipped at the surface of the litter layer.
   - If a piece crosses the plot boundary, clip it where it crosses and collect the portion that falls within the boundary.
   - If aerial pieces are encountered, only collect pieces located < 1.3 m above ground level.
   - FWD may be attached to larger pieces of woody debris. Clip and collect all portions ≤ 1.0 cm in diameter. For example, branches ≤ 1 cm should be clipped from a larger stem at the point where the diameter transitions from > 1 to ≤ 1 cm. The remainder of the piece should be placed outside the microplot, but not in the woody debris sampling area. This will allow further unobstructed sampling within the microplot.

2. Place all FWD into a paper sample bag(s). Pieces may be cut into convenient-sized portions to facilitate bagging the material.

3. On each bag identify the sample material (i.e., FWD), and record the network label, the number of the microplot it was collected from, the sample number (i.e., bag "1 of 1", "1 of 2", etc. depending on how many sample bags were used for FWD at that microplot).

4. Oven-dry samples in a forced-air drying oven at 55°C until a constant weight is obtained (generally for 24 h, but time may vary depending on the oven and load).

5. Weigh oven-dry samples to the nearest 0.1 g.

   Note: If oven-drying cannot be initiated within 24 h of collection, air-dry the samples to prevent decomposition. To air-dry, leave sample bags open in a warm, dry room to let excess moisture escape. Carefully rotate the vegetation in the bags to ensure even drying. This process can continue for several days if necessary.

Completing the Microplot Clipping Field Card (9a)

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first ongoing measurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Nominal Plot Size (ha):** Record the area of the microplot to the nearest 0.0001 ha. A circular plot with a 0.56-m radius will have an area of 0.0001 ha.

6. **Measured Plot Size (ha):** Record the measured area of the microplot to the nearest 0.0001 ha. A circular plot with a 0.56-m radius will have an area of 0.0001 ha. The measured area excludes portions of the plot that were not measured due to inaccessibility.

7. **Plot Type:** Enter a three-character plot type code:

   - **MPC:** Circular microplot
   - **MPS:** Square microplot.

8. **Microplot Number:** Microplots should be numbered consecutively clockwise from the 0-m mark on Transect 1. Enter data for the correct microplot number (1–4) from which the sample was collected. For each microplot, record if it was sampled (Y) or not sampled due to hazard, obstacle, or falling into a non-forested site (N) in the Microplot Number box. If the microplot was not measured, explain in the comments section.

9. **Sample ID:** Use the following codes to identify the type of material being reported:

   - **1:** Shrubs and trees < 1.30 m
   - **2:** Herbs
   - **3:** Bryoids
   - **4:** Fine woody debris
   - **5:** Small stumps

10. **Oven Dry Weight:** For each microplot, record the total oven-dry weight of each type of material. If a material type was absent at a microplot, enter an oven-dry weight of 0.0 g.

11. **Comments:** Enter comments on microplots on the appropriate line.

Forest Floor Samples (Mineral Sites Only)

Determining What to Collect

In sites with shallow organics overlying mineral soils, a forest floor sample is collected from each of the four microplots after all of the vegetation and FWD pieces have been removed. The forest floor includes the litter, fibric, and humus layers above the mineral soil. This material will be dried, weighed, and analyzed (see Appendix M). The following should be collected from each microplot:

- Collect the forest floor from the main forest substrate. In most circumstances, this would be the material (LFH layers) lying on top of the mineral soil. It can also include decayed wood that is part of the forest floor. No mineral soil should be contained within the sample.

- If possible, place the template directly on the ground, avoiding placement on obstacles such as woody debris, large rocks, and stumps. If the obstacle is very large and cannot be avoided, a smaller area of the forest floor may be sampled within the microplot. If an obstacle is preventing collection of soil or forest floor samples within the area of the microplot, follow instructions as described above in "Anomalous Conditions."

  Note the area sampled on the field card, in the comments, **and** on the sample labels.

- If a cryptobiotic crust is encountered, it should be collected **separately** from mineral soil, forest floor, or organic soil. It should be collected as a single, separate layer. Mineral soils underneath the cryptobiotic soils will be sampled in the mineral bulk density samples. Separation of the organic from mineral materials will take care.

  The same attributes recorded for forest floor should be recorded for cryptobiotic crusts. (Information for cryptobiotic samples can be written in the forest floor section of the tally card, but a cryptobiotic sample does not replace a forest floor sample. If they are both present, collect them both separately. In the "Horizon" section of the field card, CRYPTO should be recorded. Comments should be included on the field cards and sample labels.

Collecting Forest Floor Samples

The forest floor is sampled as a complete unit using a sampling frame (see Appendix N).

1. Make sure that all live vegetation, woody debris, and green moss and lichens have been removed from the microplot sampling area.

2. Place the 20 × 20 cm (inside dimensions) aluminum sampling frame over the sampling point, taking care not to compact the sample.

3. Using a sharp knife, handsaw, and/or clippers, carefully cut through the forest floor along the inner surface of the frame to separate it from the surrounding organic material and the soil underneath.

4. Ensure that the forest floor sample extends to the point where it hits mineral soil.

a. Carefully separate organic material from mineral soils. Distinguishing the organic/mineral interface can be more difficult on sites with humus forms that are well mixed (e.g., a moder humus over an Ah layer).

b. Technically, a soil horizon is classed as mineral soil when it contains organic carbon content ≤ 17% by weight. For field purposes, the determination is usually made by hand, feeling for the presence of mineral materials to judge the organic/mineral interface.

c. Where the determination is unclear, make a best judgment call in the field and then note it on the tally card in the comments section. Appropriate measures will be taken in the lab processing of the samples.

5. With a hand trowel, use inward scooping motions to remove the entire volume of forest floor from within the confines of the sampling frame. No mineral soil should be included in the forest floor organic sample.

   If there are rocks and gravel *within* the litter, they should be included. They can only be discarded if their mass is measured and recorded on the field card *and* on the soil sample label; otherwise submit **whole** sample. If discarding a large rock *within* the dimensions of the forest floor organic sample, weigh the rock to the nearest gram, and note its mass in the comments section on the field card *and* on the soil sample label. This information will be used to adjust the volume of the sample in the lab.

6. Working over a tarp, place the entire forest floor sample into a paper sample bag, complete the pre-printed label with a waterproof marker, and affix to the outside of the sample bag. You may have to double bag samples or use a plastic overbag to prevent tearing and loss of sample material. Make sure each bag is clearly labeled.

   In some areas, more than one bag might be required to hold the sample. If so, label the bags with identical information, and then add "1 of 2", "2 of 2", etc., respectively. If no sample is taken, label an empty bag for the microplot.

7. Measure the distance from the top of the forest floor organic sample (0 cm) to the forest floor organic/mineral soil interface at four different locations within the excavation (e.g., at the four corners of the sample). Record the average depth to the nearest 0.1 cm. This measurement will be used to calculate the volume of the excavation, and in turn, the bulk density of the forest floor organic layer.

Bulk Density Sampling

Mineral Soil Samples

Extreme care must be taken in the sampling of mineral soils for bulk density measurements, as there are no quality assurance methods for these procedures. The field crew member responsible for bulk density sampling should perform a number of practice excavations before actual data collection to ensure that consistency of methods has been achieved (see Appendix N). If crew members do not sample bulk density regularly, they should practice under the supervision of a soils specialist.

Mineral soil samples are collected in the microplots, after the forest floor samples have been removed. To calculate mineral soil bulk density, seven mineral soil samples will be collected in the field for lab analysis (see Appendix M). The exact volume of each sample

will be determined in the field. In total there will be seven samples: four samples from 0 to 15 cm depths, two samples from 15 to 35 cm, and one sample from 35 to 55 cm. They will be collected as follows (Figure 11.2):

- At the microplot that best represents the site
  - one mineral soil sample from 0 to 15 cm
  - one mineral soil sample from 15 to 35 cm
  - one mineral soil sample from 35 to 55 cm
- At a second microplot sampled
  - one mineral soil sample from 0 to 15 cm
  - one mineral soil sample from 15 to 35 cm
- At the remaining two microplots
  - one mineral soil sample from 0 to 15 cm

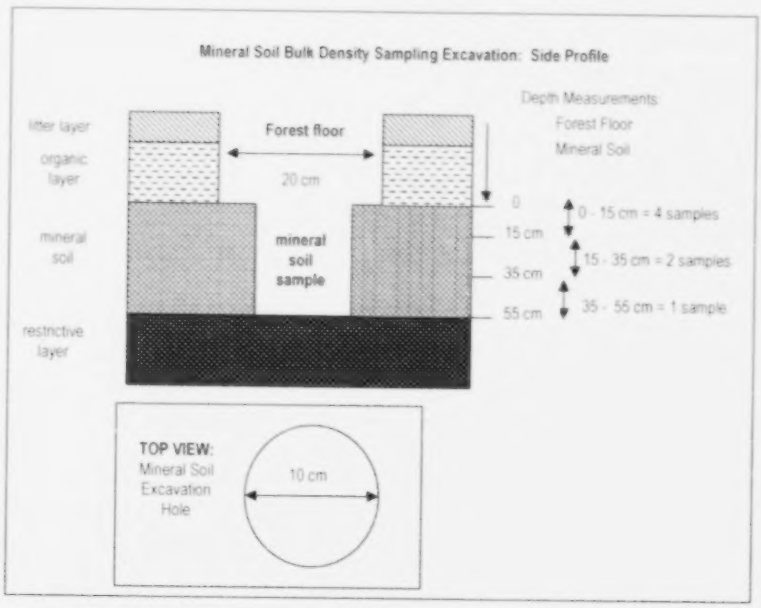


Figure 11.2 Bulk density sample excavation for mineral soils.

Collecting mineral samples at continuous depths is important for the following reasons:

1. The highest amount of carbon is in the upper depths of mineral soil. For analysis, the top two mineral samples must be continuous with one another.
2. Due to site-specific reasons, such as rocks in the mineral layer, excavating at the specified depth increments may not always be possible. If excavating at

the specified depths is not possible, still attempt to take three continuous samples at successive depths.

3. If continuous samples at the targeted depths are not possible, note why it is not possible on the tally card in the comments section. Note the depth that the sample was taken on the tally card, on the label inside the sample bag, and on the outside of the sample bag.

4. One of the microplots will have three continuous bulk density samples taken. The microplot chosen should represent the soils within the site. For example, if most of the site has mineral soils covered with shallow organics, choose the microplot that exhibits these qualities. Use the results from the surface substrate stations to aid in deciding which microplot is most representative.

Mineral Soil Samples (0–15 cm)

Upon extraction of the forest floor layer, further clear an area of the surrounding organic material that is larger than the template (e.g., 50 × 50 cm) to begin excavation of the mineral soil samples.

Level an area about 20 × 20 cm and excavate a round hole inside the level area for extracting the Mineral 1 sample. The hole should be about 10 cm in diameter (for a 15 cm deep sample) to allow for the extraction of ≥ 1.0–1.5 L of mineral soil.

1. Using inward scooping motions and working over a tarp, extract the loose soil and gravel (< 7.5 cm) from the hole using the long-handled soup spoon or shallow gravy ladle and place in a 10-mm, heavy-duty plastic bag.

2. During the excavation, take extreme care not to compact the sides of the hole, as this will affect the bulk density of the sample. Avoid soil compaction during excavation by always keeping the handle of the trowel pointed in towards the center of the hole, with the blade of the trowel pointing outwards.

3. Clean the face of the hole using the hand-clippers or knife. All roots extending into the hole must be clipped and included in the sample.

4. Using your fingers or knife, smooth the surface of the hole and make sure there are no voids (e.g., where coarse fragments may have been extruding). If there are voids, the dimensions of the hole must be extended to accommodate a reasonably smooth surface.

5. Once the excavation is complete, line the hole with a 5-mm weight plastic bag and fill the bag with the glass beads until the surface of the beads is flush with the top of the excavated hole.

6. Remove the bag and pour the beads into a 1.0-L graduated cylinder filling the cylinder. The volume of the remaining beads can be measured using the 100-mL cylinder for greater accuracy. Record the total volume, to the nearest 10.0 mL on the field card along with the pit number, and mineral layer number.

7. If large rocks (> 7.5 cm) were removed from the hole, do not include in sample bag (though any adhering soil should be cleaned off and placed into the sample bag). Weigh rock to the nearest gram. Discard the rock, but be sure to include mass of removed rock on sample labels and tally

cards. This information will be used by the lab to adjust the volume of the sample for bulk density determination.

8. Complete two pre-printed waterproof soil labels with a *waterproof* marker. Include one inside the bag with the sample and affix the second to the outside of the sample bag.

9. Record the required attribute information, making sure that field cards and labels agree.

10. Measure the top and bottom depths of the excavated hole to the nearest 0.5 cm and record on the field form and label.

Mineral Soil Samples (15–35 cm and 35–55 cm)

1. Choose a feature in the excavated hole that marks the depth of the previous excavation. A golf tee or aluminum nail may also be used to mark the depth. **It is important to excavate samples at depths that are continuous with the previous excavation.**

The second and third excavations will require extra care and effort to obtain. The top layer of the initial excavation surface should be cleared to a broad and level surface (e.g., 50 × 50 cm) before successive deeper holes are excavated (Figure 11.3). This larger area can be used for the pedogenic layer description and coarse fragment content estimation.

2. Perform the second excavation from 15 to 35 cm mineral depth using the same method as the first excavation. The third excavation should be dug from 35 to 55 cm mineral depth.

3. Measure volume of each sample to the nearest 10.0 mL using the glass bead method described above.

4. Record the total volume to the nearest 10.0 mL on the label and on the field card, along with the microplot number and mineral layer number. Measure the top and bottom depths of each sample taken to the nearest 0.5 cm and record on the label and field card.

5. Complete two sets of pre-printed soil labels with a waterproof marker. Include one label inside each sample bag and affix the second label to the outside of each sample bag.

6. Record the required attribute information on the field card, making sure that field cards and labels agree.

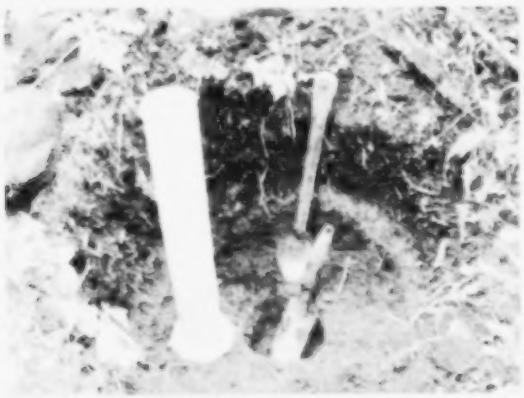


Figure 11.3 **Photograph of soil mineral sample excavation 35–55 cm.** Photo courtesy of Leigh Black.

Commonly Encountered Problems during Mineral Soil Excavation

Because of the many different types of soil found in the field, it may not always be possible to obtain soil samples using the excavation method or using a soil core. Personal judgment may be required in determining the most appropriate way to collect samples. The following section provides some suggestions of how to overcome these problems.

Rocky Soils

In soils containing a high percentage of rocks, several attempts may be required to obtain a continuous sample to 55 cm. If you are unable to obtain the continuous sample to 55 cm on your first attempt, try again at the next microplot sampled. If a continuous sample to 55 cm could not be obtained at any of the microplots, make a note in the comments section of the tally card explaining the reason (e.g., "hit bedrock after three other attempts at different locations in site" or "entire site filled with large coarse fragments"). Label an empty bag and send this back with the samples that were successfully obtained. Sending an empty sample bag and explaining why the sample was not obtained in the field will help the lab staff keep better track of the samples (i.e., the lab staff will know that a sample has not been lost or misplaced).

Very Sandy Soils (or Very Dry Soils)

In very sandy or dry soils, the excavated walls may collapse when attempting to extract the sample. In this case, a tube probe method may be employed to collect the sample. A tube probe method is described in USDA (2002). It involves removing the forest floor from an area and hammering a tube probe into the ground. A shovel is used to dig around the soil coring head while it is still in place. The soil corer is tilted to one side and the blade of a shovel is inserted underneath the base of the core. The blade of the shovel holds the sample in place as the corer is removed from the soil. Depending on the soil type, this technique may require some practice or the use of a partner.

Sloped Terrain

The soil bulk density should be sampled on as level a surface as possible. In sloped terrain, the excavated hole should be in the flattest location possible. This may mean clearing away a few centimetres of the Ae or Ah on one side to ensure a flat surface for sampling.

- For the first excavation, measure the average depth of the hole after a few centimetres of Ae or Ah have been removed on one side.
- Note in the comments section that the depth was measured on a slope along with the percent of the slope.
- Only use glass beads (not water) for the volume measurement.

Permafrost Frozen layer

If a frozen layer is encountered, only sample to the frozen substrate. Record the depth of the frozen layer. For example, if a frozen layer occurs at a depth of 27 cm, collect a 0–15 cm and a 15–27 cm sample.

Unobtainable Samples

If a sample was not obtained due to site-specific reasons, make a note in the comments section of the field card explaining the reason (e.g., "hit bedrock after three other attempts at different locations in site" or "wasp nest, microplot could not be sampled") and label an empty bag and send this back with the samples that were successfully obtained. Make sure to note why the sample was not obtained on the field card in the comments section and the label inside the empty sample bag. Ensure that the field forms are completed correctly for not completed samples.

Organic Soil Samples

Sampling of deep organic soils (> 40 cm) will provide a series of samples of known volume that will be used for bulk density determination and chemical analysis. The goal is to collect one 1- to 1.5-L sample from each layer. There are no forest floor samples in deep organic soils as the forest floor is part of the organic substrate.

Where deep organic soils are present, collect one sample of each of the following organic layers from ***one*** representative microplot:

- 0–15 cm
- 15–35 cm
- 35–55 cm
- 55–75 cm.

Deep organic soils and wetland sites should be sampled during the driest portion of the field season.

1. Choose **one** of the microplots to do the four continuous organic bulk density samples. The microplot chosen should be representative of the soils around plot center. For example, if the area around the plot center has organic soils to 50 cm over bedrock, choose the microplot that exhibits these qualities. Use the

results from the surface substrate stations to aid in deciding which microplot is most representative.

2. Make sure that all live vegetation, live bryoids, and woody debris have been removed from the microplot sampling area. The soil surface after biomass removal represents "zero depth" for organic soil sampling.

3. Using a 20 × 20 cm (inside dimensions) aluminum sampling frame, cut, collect and measure organic layers in contiguous intervals from the chosen microplot.

   - Place the aluminum sampling frame over the sampling point, taking care not to compact the sample. Using a sharp knife, handsaw, and/or clippers, carefully cut through the organic layer along the inner surface of the frame to separate it from the surrounding organic soil.

   - Excavate the area adjacent to one side of the sampling frame until the required depth is reached. Use a serrated bread knife to cut along the bottom of the frame before removal of the sample (Figure 11.4).

Figure 11.4 **Photograph of organic soil sample excavation 35–55 cm.** Photo courtesy of Michele Jones.

   - Collect four samples from successive depths to the mineral soil, rock surface, frozen layer, or 75 cm, whichever is encountered first. If there are mineral soils below the deep organic soils, you do not need to collect mineral samples in addition to the organic samples. For example, if the organic soils stop at 50 cm, you only need to collect to 50 cm (35- to 55-cm sample). Document your findings in the field card and label comments, and include a marked (empty) bag for the 55- to 75-cm sample.

   - If the soils are very wet, bail out as much water as possible and attempt to take the sample.

4. Record the distance to the nearest 0.5 cm from the top and bottom of each excavation (e.g., the third organic soil sample [35–55 cm] would have a top depth of 35 cm and a bottom depth of 55 cm).

5. Calculate and record the volume of the sample on the sample label:

$$template\ width \times template\ length \times (sample\ bottom\ depth - sample\ top\ depth)$$

For example, if taken using a 20 × 20 cm sampling frame, the top sample (0–15 cm) volume would be:

$$20 \times 20\,cm \times (15\,cm - 0\,cm) = 6000\,cm^3 \text{ or } 6000\,mL$$

6. For each sample, complete two pre-printed soil labels with a **waterproof** marker. Include one inside the bag with each sample and affix the second to the outside of each sample bag.

7. Record the required attribute information on the field card, making sure that field cards and labels agree.

Commonly Encountered Problems during Organic Soil Excavation

Saturated or Wetland Organics Soils

- Saturated or wetland sites should be sampled in the driest portion of the field season.
- In very wet conditions, bail out as much water as possible with each successive excavation and attempt to take the sample.
- If the sample is incredibly wet and heavy, and bringing it back poses an undue hazard, take a vertical slice of the organic layer sample, and adjust the volume to reflect the sample submitted.
- If a sampling frame cannot be used successfully, attempt to collect a sample using a soil corer. A soil coring method is described in USDA (2002).

Permafrost/Frozen layer

If a frozen layer is encountered, record where the frozen layer occurs and stop sampling (i.e., if a frozen layer occurs at a depth of 27 cm, collect a 0–15 cm and a 15- to 27-cm sample). Label an empty bag for any unsampled layers and send this back with the samples that were successfully obtained.

Unobtainable Samples

If a sample was not obtained due to site-specific reasons, make a note in the comments section of the tally card explaining the reason (e.g., "water could not be bailed out") and label an empty bag and send this back with the samples that were successfully obtained. Sending an empty sample bag, explaining why the sample was not obtained in the field, will help the lab staff keep better track of the samples (i.e., the lab staff will know that a sample has not been lost or misplaced).

Sample Labels and Shipping for Forest Floor Organic and Bulk Density Samples

Labels for Forest Floor Organic and Bulk Density Samples

Pre-printed waterproof labels should be provided to each field crew (Appendix O). **All items on the sample label must be completed** for proper processing of the sample by the laboratories. In previous programs, numerous samples have been discarded due to mistakes or inconsistencies on the labels. **Make sure labels match field cards.**

Shipping Forest Floor Organic and Bulk Density Samples

After samples have been collected, changes in the oxygen and moisture content within the sample bag can significantly alter the chemistry of the sample. To prevent this from occurring, ship samples **weekly** to a regional soil lab designated for your jurisdiction (or the soil lab at the Pacific Forestry Centre, see details below). Do not keep samples longer than a week unless they can be stored in a refrigerated area. Ship the samples using the most economical rate. There is no need to ship soil samples using expensive overnight delivery services. General rules for shipping include:

- Ship samples together, if possible.
- Avoid creating boxes that weigh > 20–25 kg.
- Label the boxes and samples clearly.
- If the samples cannot be shipped immediately, store samples in well-ventilated area to let excess moisture escape. For forest floor organic samples, carefully rotate the samples in the bags to discourage mold and fungal growth.

A completed shipping form must accompany each shipment of soil samples (Appendix O). The laboratory staff uses information on the sample shipping form to create an inventory of the samples, to assign lab numbers, and to help resolve inconsistencies on the sample label. A complete and accurate inventory of samples is critical to efficient and cost-effective processing of samples. The shipping form should be filled out and photocopied so **three** copies are on hand. Before shipping the samples, crews should completely fill out the shipping form and:

1. Send the original with the soil samples to the laboratory (regional lab addresses are listed at the bottom of the shipping form).
2. Mail one copy immediately to the laboratory in a separate envelope along with a copy of the shipping (tracking) information from the shipping service. The separate mailing of shipping forms will serve to notify the laboratory if a shipment of samples has been misplaced during transport.
3. Send the third copy to the NFI ground plot data co-coordinator for their records.

Completing the Microplot Samples Field Card (9b)

The following attribute information, together with information from the samples collected in the field will be used to report the bulk density and chemical analysis of the forest floor and soil. This card will be used for recording forest floor, mineral soil, and

organic soil sample information. Additional information will be collected from soil measurements taken from a representative soil pit (see Section 10: Soils).

Completing the Microplot Samples Card (9b) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first ongoing measurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and person 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

Completing the Microplot Samples Card (9b) Forest Floor Samples

1. **Pit Number:** Record the pit number code to indicate where the forest floor organic sample was collected (Table 11.1).

Table 11.1 Pit number codes.

Codes	Microplot
MP1	Microplot 1
MP2	Microplot 2
MP3	Microplot 3
MP4	Microplot 4
LP0	Large (representative) soil pit
PT1	Other location 1
PT2	Other location 2
PT3	Other location 3
PT4	Other location 4

2. **Sample Number:** Record a unique number for each sample collected at a given microplot number. If two samples are collected from a microplot, the first line would contain information about the first sample with its sample number (i.e., 1) and the next line would record the second sample with a different sample number (2).

3. **Horizon Measurement:** Record a code to indicate whether horizon measurements were sampled by depth or pedogenic indicator. ***These***

guidelines describe procedures for horizon sampling by depth and would be indicated by the code "D".

D Horizon sampled by depth

P Horizon sampled by pedogenic indicator

4. **Horizon:** ***This field is optional for samples collected by depth and required for samples collected by pedogenic indicator.*** Record the forest floor horizon included in **each** sample according to The Canadian System of Soil Classification (Soil Classification Working Group 1998) conventions. Forest floor organic material is comprised of litter (L), fibric material (F) and decomposed humus (H) (refer to definitions). For samples collected by depth, a combination of horizons may be recorded. Use " / " to separate horizons (e.g., L/F/H).

5. **Upper Depth of Sample (cm):** Record, to the nearest 0.5 cm, the average depth from the surface of the forest floor to the top of the collected sample. Forest floor is generally collected as a single layer with an upper depth of 0 cm. If the forest floor material needs to be separated into two samples, measure the depth to the upper boundary of the second sample (this should be the same as the bottom depth of the first sample).

6. **Average Bottom Depth of Sample (cm):** Measure average depth of the sample (from the surface of the forest floor). Depth is usually measured at the four corners of the sample to calculate an average. Record the average depth to the nearest 0.5 cm.

7. **Sample Method:** The sampling method may affect bulk density calculations. These guidelines recommend the template method for the collection for forest floor samples. Record the code that indicates the sample collection method used:

H: Sample collected using hole or template excavation method

S: Sample collected using small-diameter cores (< 60 mm)

C: Sample collected using large-diameter cores (60–100 mm)

Forest Floor Template Width (cm): Record the width of the template used for sampling the forest floor to the nearest centimetre. For example, if a 20 × 20 cm template was used the template width would be 20 cm.

Forest Floor Template Length (cm): Record the length of the template used to sample the forest floor to the nearest centimetre. For example, if a 20 × 20 cm template was used the template length would be 20 cm.

Volume (mL): Record the volume of the sample to the nearest 10 mL (cm^3). If using a template this can be calculated as volume = template width (cm) × template length (cm) × (bottom depth of sample (cm) – upper depth of sample (cm)).

8. **Comments:** Record usual findings and not measured plot details.

Completing the Microplot Samples Card (9b) Mineral and Organic Soil Sample Sections

1. **Pit Number:** Record the location where the mineral or organic soil sample was collected using the codes in Table 11.1. If the microplot was not measured, you must still complete the line (the volume will be zero). Comments should be made about any samples not.

2. **Sample Number:** Record a unique number for each sample collected at a given microplot number. If two samples are collected from a microplot, the first line would contain information about the first sample collected and would be sample number 1. The next line would record the second sample collected, which would be sample number 2.

3. **Horizon Measurement:** Record a code to indicate whether horizon measurements were sampled by depth or pedogenic indicator. If the microplot was dropped, this field will not be completed. ***These guidelines describe procedures for horizon sampling by depth and would be indicated by the code "D".***

   D: Horizon sampled by depth

   P: Horizon sampled by pedogenic indicator

4. **Horizon(s) in Sample:** ***This field is optional for samples collected by depth and required for samples collected by pedogenic indicator.*** Record the horizon(s) included in **each** sample according to The Canadian System of Soil Classification (Soil Classification Working Group 1998) conventions. For samples collected by depth, a combination of horizons may be recorded. Use " / " to separate horizons (e.g., Ah/Bt).

5. **Upper Depth of Sample (cm):** Record the depth at which the sample being described begins, to the nearest 0.5 cm. For mineral soils, the top of the uppermost mineral sample (0–15 cm) is considered the zero depth, recorded as 0.0 cm. For the uppermost organic soil, the top of the organic material is considered the zero depth, recorded as 0.0 cm.

6. **Bottom Depth of Sample (cm):** Record, to the nearest 0.5 cm, the depth of the sample. When describing soil by depth, the bottom depth indicates the bottom of the sample (e.g., 0- to 15-cm sample would have a upper depth of 0.0 cm and a bottom depth of 15.0 cm; a 15- to 35-cm sample would have a upper depth of 15.0 cm and a bottom depth of 35.0 cm).

7. **Volume of Sample (mL):** Record the volume of the sample to the nearest 10 mL.

   - Mineral samples: This measurement is the volume of beads (or water) filling each sample excavation.

   - Organic samples: If using a template this can be calculated as volume = template width (cm) × template length (cm) × (bottom depth of sample (cm) – upper depth of sample (cm)).

8. **Sample Method:** The sampling method may affect bulk density calculations. Record the code that indicates the sample collection method used:

H: Sample collected using hole or template excavation method

S: Sample collected using small-diameter cores (< 60 mm)

C: Sample collected using large-diameter cores (60–100 mm)

Organic Soil Template Width (cm): For organic soil samples, record the width of the sampling frame used for sampling organic soils to the nearest centimetre. For example, if a 10 × 10 cm template was used the frame width would be 10 cm.

Organic Soil Template Length (cm): For organic soil samples, record the length of the sampling frame used for sampling organic soils to the nearest centimetre. For example, if a 10 × 10 cm template was used the frame length would be 10 cm.

9. **Comments:** Enter comments pertaining to samples from the microplots.

11.6 Ongoing Measurement for Microplots

Establishment of Microplots

For ongoing measurement, a new set of microplots will be established for biomass and bulk density sampling. For the first ongoing measurement, these plots should be located 2 m clockwise from the original set of microplots and 15 m from the plot center. Make sure to note on the tally cards the locations of these sampled microplots.

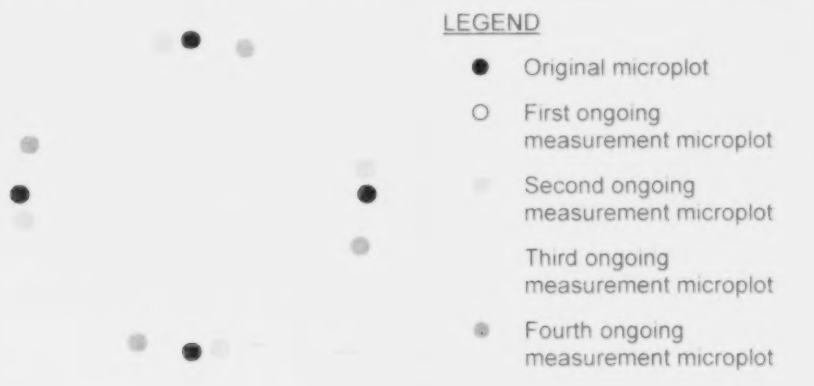


Figure 11.5 Location of microplots for ongoing measurement.

Microplots for the second ongoing measurement of biomass and bulk density, microplots should be located 2 m counter-clockwise from the original set of microplots and 15 m from the plot center (Figure 11.5). For the third ongoing measurement, the microplots should be located 2 m farther away from plot center (at 32 m and –2 m) along the transect. For the fourth ongoing measurement, the microplots should be located 4 m clockwise from the first set of microplots and 15 m from the plot center locations. Microplots for the fifth ongoing measurement will be located in the original locations.

Biomass Sampling

- Within the newly established microplots, collect shrub, herb, bryoid, small stump, and fine woody debris samples using the procedures described above.

- Clip, bag, store, and process as described above.

Forest Floor Samples

- Within the ongoing measurement microplots, collect forest floor samples as described above.

Soil Samples

It is unlikely that major changes in soil chemistry will occur between measurements. Any changes that occur will most likely be reflected in the uppermost layers of the soil. As a result, only the top layers will be sampled in the microplots.

Mineral soil samples

- Collect four 0–15 cm samples of mineral soil (one from each microplot). Determine the exact volume of each sample in the field following procedures above.

- Samples of greater depths will not be collected for ongoing measurement.

Organic soil samples

- At sites with deep organic soils, collect one 0–15 cm and one 15–35 cm sample from one microplot. Determine the volume of each sample in the field.

- Samples of greater depths will not be collected for ongoing measurement.

***Note*: If the lab was unable to complete the processing of samples collected during establishment due to missing information (generally missing volume values) or missing samples, collect the full set of soil samples.**

12.0 Large Tree Plot

12.1 Introduction

On many sites, large trees comprise the largest portion of the aboveground biomass, contributing significantly to total ecosystem carbon stocks. These trees also play a large role in energy flow and nutrient cycling, and provide habitat for many organisms. The Large Tree Plot is established at all ground plot centers for collecting information on all large trees. This information will be used to calculate total volume and gross total biomass, assess site information , and determine site potential. Additional information will be collected to assess forest health.

12.2 Objectives

- To collect detailed information for large trees (≥ 9.0 cm at diameter breast height [dbh]) to enable the calculation of:
  - total tree volume (m^3/ha). Includes aboveground volume inside bark of the main stem, including stump and top of all standing live, fallen live, and dead standing trees;
  - total aboveground tree biomass (kg/ha);
  - site index for the dominant and co-dominant trees of the major species;
  - site age and site height;
  - Lorey height;
  - annual growth ring width analysis;
  - basal areas and stem densities for standing live, fallen live, and standing dead trees; and
  - various biodiversity indices.

12.3 Definitions

Tree: For this inventory, a tree is defined as a woody plant, usually with a single stem and definite crown that can reach a mature height of 5.0 m somewhere within its natural range.

Dead Tree: Trees that are obviously dead or roots separated from the ground and expected to die very shortly.

Fallen Trees: Trees that are not self-supporting.

Large Tree: For this inventory, a large tree is a "tree" that is ≥ 1.3 m in height and ≥ 9.0 cm dbh. Large trees include all live standing, live fallen, and dead standing trees.

Live Tree: Trees that have enough foliage to keep them alive (live cambium is present), and are rooted into the ground. Lack of foliage for some species, of course, is no indication of death during some seasons.

Lorey Height: Lorey's mean height weights the contribution of trees to the stand height by their basal area. Thus Lorey's mean height is calculated by multiplying the tree height (h) by its basal area (g), and then dividing the sum of this calculation by the total stand basal area (Brack 1999).

Site Tree: Site trees are selected using defined criteria. The selected site trees have a height (called the Site Height) and an age (called the Site Age), which are used to calculate the site index for the stand.

Standing Tree: Trees that are self-supporting (i.e., the tree would remain standing if all supporting materials were removed).

Tree Species: For this inventory, a tree species is defined as a species listed in Appendix E: NFI – Tree Species List. The species on this list are based on the "tree" definition. Tree species are listed by scientific name; common name; and a code for genus, species, and variety.

For this inventory, tree species are recorded using accepted standard codes, which generally adhere to the following rules:

Genus: Record the genus of each tree using the first four letters of the scientific genus name.

Species: Record the species of each tree using the first three letters of the scientific species name.

Variety: Record the variety of each tree (if applicable) using the first three letters of the scientific variety name.

***Note*:** In cases where there the genus/species code combination is the same for more than one tree species, consult Appendix E: NFI – Tree Species List, for the correct code to use.

12.4 General Procedures

Information from field-collected large tree attributes will be used to calculate various values including site index, stand height, basal area by tree status, stem density by tree status, total unique large tree species, crown length, volume, and biomass.

The procedures within this section are listed as they appear on the field cards but the field crew is free to measure attributes in the most efficient sequence.

1. Establish and mark the plot circumference.
2. Divide the plot into sectors.
3. Determine if trees along the plot boundary are in the plot.
4. Number the trees in the plot.
5. Complete the header information on the field cards.
6. Collect the attributes for large trees.
7. Determine the site tree selections and collect age data as required.

Field Cards for the Large Tree Plot

Large Tree Information (10) (Appendix B, Diagram 17)
Field card for large trees in the 11.28-m plot: sector, species status, change code, diameter, height, crown class, height to base of live crown, height to top of live crown, stem map details, damage details.

Site Tree Information (11) (Appendix B, Diagram 18)
Field card for large trees in the 11.28-m plot: quadrant, tree number, species, tree type, boring diameter, boring height, tree height, field age, pro-rate length and ring count details.

12.5 Detailed Procedures

Large Tree Plot Establishment

Large trees must have their point of germination within the plot radius to be recorded as large trees. For this inventory, trees that have been "cut" above 1.3 m and are > 9.0 cm at dbh are considered large trees.

The Large Tree Plot has a radius of 11.28 m from the plot center (for square plots, the side length is 20.00 m). Establish the Large Tree Plot and number and tag all large trees within the plot. The Large Tree Plot layout is illustrated in Figure 12.1.

ree may be another species other than the above selections.

Figure 12.1 Layout for Large Tree Plot.

Within the Large Tree Plot, the crew will:

1. **Divide the plot into sectors:** Divide the plot into eight pie-shaped 0.005-ha (45°) sectors. Number the sectors in ascending order, starting with Sector 1, which is always the first sector clockwise from due north. These are the tagging or tree numbering sectors.

2. **Establish plot quadrants:** Tagging sectors are combined into pairs to have 0.01-ha quadrants (site sectors) for the selection of site trees.

3. **Mark the plot boundary:** Using a measuring tape, establish the 11.28-m plot radius from the plot center stake. On sloping plots, apply a slope correction to the radius (see Appendix I). Measure the plot radius to accurately determine the plot circumference. Mark the circumference with plot string, ribbon or paint dots as required.

4. **Measure borderline trees:** Measure distance from plot center to the central point of the tree stem at "point of germination" (generally equated with the tree pith). If the distance to the point of germination is less than or equal to the plot radius (corrected, for sloping plots), the tree is in the plot.

5. **Numbering and tagging trees:** The trees within the Large Tree Plot are numbered so that individual tree stems can be tracked over time. One such method suggested is using aluminum tree tags, secured at the base of the tree, which is discussed below. Other marking procedures or stem mapping the individual numbered trees may also be used.

6. **Use pre-numbered aluminum tags** to tag all living (standing and fallen) and dead (standing only) trees within the plot boundary that have a dbh of 9.0 cm and greater. Do not duplicate tag numbers in a plot.

    - Start with Sector 1. In this sector, affix the tags so that they face the **plot center**.
    - Tag the trees nearest the plot center first; then continue tagging outward by moving side-to-side across the pie-shaped sector.
    - As you reach the circumference of Sector 1, make the last sideways pass in the direction of Sector 2, so that the last tree tagged in Sector 1 is, as near as possible, to the first tree you will tag in Sector 2.
    - Begin tagging Sector 2. In this sector, affix the tags so that they face the circumference, not the plot center.
    - Tag the trees near the circumference first and then continue tagging inward by moving side-to-side across the pie-shaped sector.
    - Make sure the last tree you tag in this sector is the one closest to the plot center.
    - Repeat the procedures used in Sectors 1 and 2 for the remaining sectors. Remember that tags in odd-numbered sectors face the plot center while those in even-numbered sectors face the circumference.

Tagging Trees

Attaching Tags to Trees

Affix tags at the base of the tree equivalent to "high side" or highest point of the ground on the uphill side. If the tag will be highly visible in this location, move the tag around the tree at a height equivalent to high side until the tag is less visible.

1. Nail the tag to the base of the tree using aluminum nails.
2. Drive the nail slightly upward so the tag hangs away from the tree.

3. Drive the nail into the trunk just enough to hold the tag securely and yet allow for radial growth.

Note: The tree dbh location can then be determined by placing a 1.3-m stick on the nailed tag (on curved stems measure along the bole with a tape). Some field crews mark the dbh location with a spot using a black felt marker, paint dot, or lightly scribing the bark at this location for later dbh and height measurements.

Tagging Forked Trees

1. Tag the stem as a single tree if:

   - The fork occurs above 1.3 m; or
   - The stem has one measurable dbh ≥ 9.0 cm within the 11.28-m fixed-radius Large Tree Plot. The secondary stem is < 9.0 cm.

2. Tag each stem separately if:

   - The fork occurs below 1.3 m, and two or more of the fork's stems have a measurable dbh of ≥ 9.0 cm within the 11.28-m fixed-radius Large Tree Plot. Use consecutive numbers when you tag these stems (tag the stem farthest to the left first and finish with the stem farthest to the right)
   - Locate the tag at high side, ground level, directly below the fork so it is evident which tag belongs to each stem.

Completing the Large Tree Card (Card 10) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.
2. **Measurement Date:** Enter the date of information capture in the field.
3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.
4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.
5. **Plot Type:** Enter a three-character plot type code:

   - **LTC** = **L**arge **T**ree **C**ircular plot
   - **LTS** = **L**arge **T**ree **S**quare plot

6. **Nominal Plot Size (ha):** Record the intended area of the Large Tree Plot to the nearest 0.0001 ha. A circular Large Tree Plot with a radius of 11.28 m will have an area of 0.0400 ha.
7. **Measured Plot Size (ha):** Record the measured area of the Large Tree Plot to the nearest 0.0001 ha. A circular Large Tree Plot with a radius of 11.28 m will have an area of 0.0400 ha. If less than a full plot was measured due to safety or other factors, calculate and record the actual area sampled. Provide

comments as to why a full plot was not completed. For most samples, the nominal and measured plot sizes will be the same.

Completing the Large Tree Card (Card 10) Details

1. **Sector:** Record the plot sector. Sectors are numbered consecutively from north (1 to 8). This field is meant to aid field crews in the relocation of large trees in future measurement cycles.

2. **Large Tree Number:** In a clockwise direction from the north, each tree is assigned a unique number in ascending order. Record the tree number.

3. **Large Tree Genus:** Record the genus of each large tree using the first four letters of the scientific genus name (see Appendix E).

4. **Large Tree Species:** Record the species of each tree using the first three letters of the scientific species name. Tree genus, species, and variety are recorded only to the level that can be accurately identified with confidence. For example, if the species is not identifiable then only record to the genus level. Use accepted codes for unknown conifers or hardwoods. **Field crews should confirm the tree species identification with the ecological sampling crew to ensure the same species are being recorded.**

5. **Large Tree Variety:** If applicable, record the variety of each tree using the first three letters of the scientific variety name. This field may be left blank.

6. **Large Tree Status Codes:** Record the tree status code that best describes the live or dead large tree. Note that dead fallen trees are not collected in the Large Tree Plot.

   LS **Live Standing:** Live trees that are self-supporting (i.e., the tree would remain standing if all supporting materials were removed).

   LF **Live Fallen:** Live trees that are not self-supporting (i.e., the tree would not remain standing if all supporting materials were removed).

   DS **Dead Standing:** Dead trees that are self-supporting (i.e., the tree would remain standing if all supporting materials were removed).

7. **dbh (diameter at breast height) (cm):** Measure and record the dbh of all large trees (see Appendix J). Diameters should be ≥ 9.0 cm (otherwise it is counted in the Small Tree Plot). Record the dbh to the nearest 0.1 cm.

   - Determine high side ground level at the base of the tree. High side is defined as the highest point of mineral soil or a humus layer around the base of the tree, no lower than the point of germination. Breast height is 1.3 m above high side measured parallel to the tree bole.

   - Use a stake marked at 1.3 m to accurately locate dbh on straight stems. On curved stems, measure along the curve parallel to the center of the tree.

   - Mark a point on the tree where dbh is to be measured, preferably facing the plot center (use a felt pen, small paint dot, or lightly scribe bark).

- If there is an obstruction at the dbh level (such as large branches, forked stem, or large scar tissue), measure above and below the obstruction and estimate dbh at 1.3 m.

- Measure the dbh with a tight diameter tape, outside the bark, making no allowance for missing bark.

8. **Measured or Estimated dbh:** Record whether the dbh was measured (M) or estimated (E).

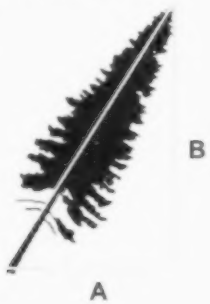
9. **Tree Height (m):** Measure the height of each large tree within the Large Tree Plot, including broken and live fallen trees. Measure all trees except where the measurement is physically obstructed, where it is unsafe to make the measurement, or when an accurate measurement is impossible. In such cases, estimate the tree height.

    - Measure the height of the tree from the ground level on the high side along the stem to the top of the stem. Record height to the nearest 0.1 m.

    - For broken stems, measure the height to the midpoint of the break.

    - For trees with a noticeable lean, calculate the height of the tree (C). Measure horizontally the distance (A) from the base of the tree to a point directly under the top of the tree. Measure the height (B) from the end of length A to the top of the tree. Using the following formula, calculate the height of the tree (C):

$$C = \sqrt{(A^2 + B^2)}$$



    - If a tree height has to be estimated, check the accuracy of your estimations by comparing the estimated tree height against measured adjacent heights.

10. **Measured, Calculated, or Estimated Height:** Record whether the tree height was measured by field crew (M); calculated, usually from height diameter curves (C); or estimated by field crew (E).

11. **Crown Class:** Crown class is a ranking by crown position of a tree in relation to other trees in the immediate area surrounding the tree being measured. The crown class is used in the selection of site trees on the plot.

    - Assign a crown class code to all large trees using the descriptions in Table 12.2.

- For trees with broken or dead tops, assess the remaining live portion of the crown relative to its present interception of light in the immediate area around the measured tree. For example, a tree was formerly in a dominant crown position but the top of the crown has died back and only the lower limbs are alive. This crown would most likely be ranked in the intermediate or suppressed position based on the current light interception of the remaining crown. If the broken or dead top has resulted in a missing crown, the crown class should be coded as "N" (not applicable).

Table 12.1 Crown class codes.

Crown class	Code	Description
Dominant	D	Trees with crowns that extend above the general level of the trees immediately around the measured trees. They are somewhat taller than the co-dominant trees, and have well-developed crowns, which may be somewhat crowded on the sides, receiving full light from above and partly from the side.
Co-dominant	C	Trees with crowns forming the general level of the trees immediately around the measured trees. The crown is generally smaller than those of the dominant trees and is usually more crowded on the sides, receiving full light from above and little from the sides.
Intermediate	I	Trees with crowns below, but extending into, the general level of the crown canopy (may include trees, shrubs, or other obstructions) immediately around the measured trees. The crowns are usually small and quite crowded on the sides, receiving little direct light from above but none from the sides.
Suppressed	S	Trees with crowns entirely below the general level of the crown canopy (may include trees, shrubs or other obstructions) around the measured trees, receiving no direct light either from above or from the sides.
Veteran	V	Mature trees that are considerably older than the rest of the stand. Usually, veterans are trees remaining from a previous forest that have survived while a new forest has been growing up around them. Different jurisdictions will have different age thresholds for the age at which a tree becomes a veteran (Dunster and Dunster 1996).
Not Applicable	N	Trees where the crown class measurement is not applicable (e.g., trees with broken top resulting in missing or minimal effective crown, standing dead trees, or fallen live trees).

12. **Height to Base of Live Crown (m):** Measure the distance along the bole from the high side ground level to the base of the live crown. The primary objective is to estimate the "effective" live crown for growth projections.

    - *Determining the live crown base.* The crown base is normally the location on the stem where live branches occupy about three-quarters of the stem circumference. If this is obviously not an effective definition, then use your judgment as to the effective crown base.

- Record the height to live crown for all live trees to the nearest metre.
- Record a "–9" for trees that are dead standing, live fallen, or have no effective crown (those having only a few green branches).
- **Height to Top of Live Crown (m):** Measure the distance along the bole from the high side ground level to the top live branches. For most samples, the tree height and the height to top of live crown will be the same.

13. **Stem Condition:** Use this field to indicate whether the main stem of the tree is intact (I) or broken (B).

14. **Crown Condition:** Examine the crown in relation to a normal live crown (lower crown loss due to self-pruning is not included). Record the appropriate code (1 to 7) from Table 12.2 (adapted from BCMELP/BCMOF 1998).

Table 12.2 Crown condition codes.

Code	Description
1	All foliage, twigs, and branches present.
2	Some or all foliage lost, possibly some twigs lost, all branches usually present.
3	No foliage, up to 50% of twigs lost, most branches present.
4	No foliage or twigs, up to 50% of branches lost.
5	No foliage or twigs. Some sound and rotting branch stubs may be present.
6	No foliage, twigs, branches, or branch stubs.

15. **Bark Retention:** Record the bark retention code that best describes the proportion of bark remaining on the tree according to Table 12.3 (BCMELP/BCMOF 1998).

Table 12.3 Bark retention codes.

Code	Description
1	All bark present.
2	Bark lost on damaged areas only (< 5% lost).
3	Most bark present, bare patches, some bark may be loose (5–25% lost).
4	Bare sections, firm and loose bark remains (26–50% lost).
5	Most bark gone, firm, and loose bark remains (51–75% lost).
6	Trace of bark remains (76–99% lost).
7	No bark (100% lost).

16. **Wood Condition:** Record the code that best describes the wood texture (soundness) of the tree and according to Table 12.4 (BCMELP/BCMOF 1998).

Table 12.4 Wood condition codes.

Code	Description
1	**No decay**.
2	**Probable limited internal decay**.
3	**Limited decay**, wood essentially hard.
4	**Wood mostly hard** but decay spreading, soft wood present.
5	**Balance of hard and soft** wood, spongy sections.
6	**More soft** and spongy wood **than hard** wood.
7	**No more hard wood**, all soft or spongy, powdery sections.
8	**Hollow shell**, outer wood mostly hard or firm.

17. **Azimuth to Tree (°):** Stem mapping is used to relocate the plot center and to aid in ongoing measurement. Ideally, all large trees in a plot would be stem mapped, but this is left as optional for the NFI plots.

    - For stem-mapped trees, measure and record the azimuth from the plot center pin to the face of the tree (to the nearest degree).

      Note: A minimum of 3–5 trees surrounding the plot center should be stem mapped to relocate the plot center pin in future measurements. These trees should be located in a triangular formation around the plot center. Insert a nail in the selected trees to be stem mapped near ground level. Measure from this nail to the plot center pin and record the distance and bearing to the plot center.

18. **Distance to Tree Face (m):** For stem-mapped trees, measure and record the horizontal distance from the plot center pin to the face of the tree at ground level (to 0.01 m).

19. **Damage Agents:** Assess all large trees, dead or alive, within the Large Tree Plot for damage agent(s). Damage agents are frequently associated with decay, rot in the wood, or factors affecting overall tree vigor. They may include non-biological (abiotic) injuries, disease, insects, treatment injuries, and animal damage. Refer to Table 12.5 for a comprehensive list of codes and descriptions of damage agents.

    - Record the damage agent(s) for each tree.
    - Record "0" if no damage agent is observed.
    - When the tree has more than two damage agents, list the most important two damage agents.
    - In many cases, damage such as forks and scars may be evident but the damage agent is not known. In these instances, record a "U" in the damage agent field.

Table 12.5 Damage agent attributes and descriptions.

Damage agent type	Damage code	Damage agent
Non-biological (abiotic) injuries	NB	Fire
	ND	Drought
	NF	Flooding
	NG	Frost
	NH	Hail
	NK	Fumekill
	NL	Lightning
	NN	Road salt
	NR	Redbelt
	NS	Slide
	NW	Windthrow
	NY	Snow or ice
	NX	Scarring and rubbing
	NZ	Sunscald
Diseases	DB	Broom rusts
	DD	Stem rot
	DF	Foliage disease
	DL	Disease-caused dieback of leader
	DM	Dwarf mistletoe
	DR	Root disease
	DS	Stem disease
Insects	IA	Aphids
	IB	Bark beetles
	ID	Defoliators
	IS	Shoot insects
	IW	Root and terminal weevil
Mite damage	M	Mites
Treatment injuries	TC	Chemical
	TL	Logging
	TH	Harvested
	TP	Planting (incorrectly planted)
	TM	Other mechanical damage (non-logging)
	TR	Pruning wound
	TT	Thinning or spacing wound
Animal	AB	Bear
	AC	Cattle
	AD	Deer
	AE	Elk
	AH	Hare or rabbit
	AM	Moose
	AP	Porcupine
	AS	Squirrel
	AV	Vole
	AX	Birds
	AZ	Beaver
No detectable abiotic or biotic damage	O	No detectable abiotic or biotic damage
Damage evident but causal agent unknown	U	Damage evident but causal agent unknown

20. **Damage Location:** This field indicates the location of the damage on the individual tree. Enter a one-digit code indicating the portion of the tree that is affected:

- **1** Lower third only
- **2** Middle third only
- **3** Upper third only
- **4** Lower and middle third
- **5** Middle and upper third
- **6** Lower and upper third
- **7** Entire tree
- **0** Below ground
- **–1** Not applicable (i.e., no detectable abiotic or biotic damage)

21. **Severity:** This field indicates the severity of the damage agent and its effect on the tree (Table 12.6).

Table 12.6 Severity codes.

Code	Severity	Effect
L	Low	Damage agent appears to have minimal impact on tree growth or vitality.
M	Moderate	Damage agent has some obvious impact on a portion of the tree but its impact is limited.
H	High	Damage agent has obvious impact on the tree with evidence of decay or suppression of tree growth evident.
C	Critical	Damage agent has critically impacted and killed the tree (dead trees) or the damage agent is severely impacting the tree and is expected to kill the tree in the near future.
U	Unknown	Damage agent is evident on a "dead" tree but no evidence that this specific damage agent killed the tree.

22. **Comments:** Record the tree number and any comments on large trees in the comments section.

Site Tree Information

Site trees are a measure of site productivity expressed by the height-to-age relationship of dominant and co-dominant trees (USDA 2005). Site trees will be selected from each of

the NFI samples to determine site productivity. The objectives for measuring site trees are to:

- calculate site index of the dominant and co-dominant trees,
- calculate site age and site height,
- calculate Lorey height, and
- calculate annual growth from ring width analysis.

The height and age data from these samples can be used for various purposes such as stand age calculations, growth relationships, and site index calculations. Further analysis of the core samples can also be used to interpret correlations related to insect, disease, or other environmental stresses.

Selection of Representative Site Trees

Site index is used in projecting the forest stand growth and stand structure into the future. To calculate site index, site trees are selected using defined criteria. The selected site trees have a height (called the Site Height) and an age (called the Site Age), which are used to calculate the site index for the stand (Iles 2003).

For all NFI plots, select site trees using the descriptions outlined below. The following types of trees are measured for age and height:

1. **Top height (T):** The largest diameter (dbh) tree in the Large Tree Plot, regardless of the species. It must be alive and dominant or co-dominant in status. Select one top height tree from the northeast quadrant (NE) from the Large Tree Plot for age and height determination.
2. **Leading species (L):** The largest diameter (dbh) tree in each quadrant of the Large Tree Plot, of leading species by basal area. It must be alive and dominant or co-dominant in status. It must not be a residual of a former stand. Select one leading species tree per quadrant for age and height determination.
3. **Second species (S):** The largest diameter (dbh) tree in each quadrant of the Large Tree Plot, being the second leading species by basal area and having > 20% of the basal area in the plot. It must be alive and dominant or co-dominant in status. It must not be a residual of a former stand. Select one second leading species tree per quadrant for age and height determination.
4. **Other major species (O):** The largest diameter (dbh) tree in each quadrant of the Large Tree Plot, of all species, other than the leading or second leading species, having > 20% of the basal area in the plot. It must be alive and dominant or co-dominant in status. It must not be a residual of a former stand.
5. **Residual (R):** A residual tree is a living remnant of a former stand; in even-aged stands, it is the occasional (< 25 per ha) large stem of an age class older than the stand as a whole. Typically, these trees may have larger diameters, a higher incidence or indications of decay, thicker bark, larger branching, and "ragged" or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees. **Residual trees are called Veterans in some inventories.**
6. **Non-standard selection type (N):** An additional tree(s) that is selected in a non-standard manner (at the discretion of the field crew). This flexibility is for

special cases where the field crew feels that adequate information cannot be provided following the standard procedure alone. For example, a selected tree might be unsafe to measure. Alternatively, the plot may be in a patch of recently killed trees where all trees are dead where it would be necessary to select dead trees for age. Comments must be supplied on the tally card to explain why the tree was selected.

The selection of the leading species, second leading species, and other major species are based upon the species' basal area within the plot. On many samples, the leading, second species, and other major species may be obvious. In these cases, it will not be necessary to calculate the basal area in the plot on site. In some plots, there will be multiple species or two species, which have approximately the same basal area or species that have around the cutoff 20% required for a major species. It will then be necessary to calculate the basal areas on site. If large tree information has been collected on electronic field data recorders, the basal area calculations can be performed within the program. When using paper tally cards, a paper worksheet and a calculator can be used to calculate the basal area of all species in the field (see Appendix K: Calculation of Basal Area).

In some samples, there will be few or no trees large enough to be measured in the Large Tree Plot, while in others most stems will be large trees. The following are some suggestions on calculating the species order:

- **Small trees only:** These immature stands or low volume small diameter stands will have most stems in the Small Tree Plot with few if any large trees. To determine the leading, second, and other major species, use the live tree count from the Small Tree Plot. Total the tree count by species and total for all species, then calculate the percentage of each species as you would for the Large Tree Plot.

- **Mixed diameter stands:** These stands will have most stems either greater or less than 9.0 cm (typically 6–12 cm). The worksheets in Appendix K can be used to calculate the basal areas.

- **Large tree stands:** Use the worksheets in Appendix K to calculate the percentages for each species.

In younger stands or slow-growing low site stands, the trees selected for site measurement may be < 9.0 cm dbh and not be one of the trees tallied in the Large Tree Plot. They may also be outside of the Small Tree Plot. Care must be taken to evaluate the full 11.28-m quadrant for site tree selection.

Coring Representative Site Trees in Stands with Few Large Trees or Species Subject to Disease

In most cases, the site trees selected within the Large Tree Plot are cored to determine age and radial increments. If a site tree within the permanent sampling area is likely to suffer long-term health consequences due to coring (e.g., small diameter trees and some species of deciduous trees), it is advised to select a surrogate site tree from outside the permanent sample area to sample in its place to avoid introducing damage to trees that are meant to be monitored in perpetuity.

If a surrogate site tree is cored, all large tree information and site tree information should be recorded for it as if it were another tree in the Large Tree Plot (both data sets are required for age and site tree calculations). To prevent these trees from being inappropriately lumped with the large trees "in" the permanent sample area during analysis, use the following conventions when numbering surrogate site trees:

- Surrogate site trees (< 9 cm dbh) should be assigned a tree number between 8000 and 8999.
- Surrogate site trees (≥ 9 cm dbh) should be assigned a tree number between 9000 and 9999.
- Trees numbered from 8000 to 9999 will be used in site age, site index, site index genus, site index species, gross volume increment, and gross volume mean annual increment calculations, but will skipped over in all other analysis.
- Attach a tag to the tree with the tree number recorded on the tag; record azimuth and distance from plot center on the large tree information card.

Note: An easy way to keep track of which tree within the plot is being represented by the surrogate site tree is to number the surrogate tree by adding 8000 (tree < 9 cm dbh) or 9000 (tree ≥ 9 cm dbh) to the number assigned to the tree being represented.

Collecting Field Ages

Field age (years): Determine the age by a ring count and enter the data in the field count section of the tally card. The count will be the number of full rings. It is up to the field crew to determine when diameter growth has essentially stopped for the season. Detailed procedures on counting, storing, and shipping tree age cores are contained in Appendix L.

- Bore all trees on the side facing plot center.
- If you need to "mark" periodic rings to help establish age, please use a pencil, not a pen. Pen marks tend to soak into the core, making later analysis difficult.
- The pith should be included in sample tree cores as often as possible to ensure accuracy. If you can get within 5 years of the pith and can confidently estimate the remainder, there is no need to redo the tree boring. Record the actual age counted on the core at the level where the tree was bored. Adjustments for years to reach that point will be done in the lab and office analysis.
- On large trees, or trees that have rotten centers, record the code for "ROT in the prorate section," count the age of the sound portion, and measure the length of the sound core.
- In some cases, the center of the tree cannot be reached as the increment borer was not long enough to reach the center. In this case, enter the code "CRC" (Cannot Reach Center) in the prorate section, count the age, and measure the core length.
- During the lab and office analysis, calculate the total ages for these trees.

Determining Suitable Site Tree Heights and Site Tree Ages

Site trees are selected based primarily on their diameter at breast height within a fixed-area plot. Not all of these trees will be suitable for estimating site index. Some of these trees will have significant damage affecting their height growth. These trees may also have been growing under an overstory, which has severely suppressed the growth of the tree. Field crews should assess each selected site tree to evaluate if any factor has affected the tree height or age and would limit the use of the tree for calculating site index. Tree heights and ages are still valuable for the determination of stand age and stand height.

Suitable Site Height: A tree may meet the site tree selection criteria and still not provide a suitable height for site determination. Examples of trees that would not be suitable for height include:

- significant broken top
- significant dead top
- fork or crook that significantly affects height growth
- abnormally high amount of scarring or other damage that may have affected height growth (e.g., significant mistletoe infection).

  Note: Significant refers to a reduction in the height of the tree compared to what it would be if undamaged. The reduction is great enough that a reliable site index estimate could not be obtained from the tree measurements.

Record a code to indicate whether the tree is suitable to be used in compiling site height, and site index for the sample:

- **Y** the tree is suitable
- **N** the tree is not suitable.

Suitable Age: A tree may meet the site tree selection criteria and still not provide a suitable height for site determination. Examples of trees that would not be suitable for age include:

- **Residual trees:** A residual tree is a living remnant of a former stand; in even-aged stands, it is the occasional (< 25 per ha) large stem of an older age class than the stand as a whole. Typically, these trees may have larger diameters, a higher incidence or indications of decay, thicker bark, larger branching, and "ragged" or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees. Residual trees may also be trees left after logging or other disturbances have removed the adjacent trees. These trees may have been significantly suppressed under the previous stand and only recently being in a dominant or co-dominant crown class.

Record a code to indicate whether the tree is suitable to be used in compiling age and site index for the sample:

- **Y** the tree is suitable
- **N** the tree is not suitable.

Lab Compiled Attributes for Annual Growth Information

Additional information will be acquired for trees from which core samples have been taken. Age and height data may be used for purposes such as ecological correlation studies. These studies may require additional screening for tree suitability. The screening will rely on the physiological age values, age prorate information, and additional crew comments to screen trees with rot, suppression, or other damage.

The following attributes will be compiled in the lab:

- prorate data ring count (years)

- cored age (years)
- age correction (years)
- total age (years)
- annual growth (mm).

Completing the Site Tree Information Card (Card 11) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.
2. **Measurement Date:** Enter the date of information capture in the field.
3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.
4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

Completing the Site Tree Information Card (Card 11) Details

1. **Quadrant:** Record the quadrant where the selected tree is located. The available selections are:
    - **NE** North East quadrant
    - **SE** South East quadrant
    - **SW** South West quadrant
    - **NW** North West quadrant
    - **OP** Out of Plot selection
2. **Large Tree Number:** Record the unique number of the selected tree. If trees were selected from outside the plot for coring, please assign them a tree number between 8000 and 8999 (trees with dbh < 9.0 cm) or 9000 and 9999 (trees with dbh ≥ 9.0 cm) so that they are not tallied as part of the Large Tree Plot.
3. **Site Tree Selection Type (Site Type):** Record the site tree selection criteria used:
    - **T** Top height tree (1 potential tree)
    - **L** Leading species tree (4 potential trees)
    - **S** Second leading species tree (4 potential trees)
    - **O** Other major species (4 potential trees per species after leading and second species selection with > 20% basal area)
    - **R** Residual trees (select 1–2 representative trees)

- **N** Non-standard tree selection

4. **Boring Diameter Outside Bark (cm):** Measure the diameter outside of the bark at the location of boring and record to the nearest 0.1 cm (usually the dbh).

5. **Boring Height (m):** Bored height is the height (above the high side ground level) where the boring was made. Record the bored height to the nearest 0.1 m. The bored height in most instances will be 1.3 m (e.g., breast height).

6. **Suitable Height (Y/N):** Record a "Y" for "yes" if the tree height has not been significantly affected and is suitable for calculating a reliable site index estimate. Record an "N" for "no" if the tree height has been significantly affected.

7. **Field Count Age:** Core samples will be counted in the field to obtain age (record the field age count age for the complete core or the partial cores). If the tree was previously aged, (at establishment or previous visits), it is not necessary to core the tree again. Simply record a "-8" in the field count column (the current age will be calculated in the office). Field age count data will also be useful in determining succession interpretations. The cores will be recounted under magnification, by CFS lab technicians, to determine the actual age and annual growth increment.

8. **Suitable Age (Y/N):** Record a "Y" for "yes" if the tree is not a residual in the stand. Record an "N" for "no" if the tree is a residual.

If the full age core is not available due to rot or the increment borer was not able to reach the tree pith, the following information is required to enable the calculation of the total tree age in the laboratory.

9. **Pro-rate Code:** When a full boring is not possible record a code to indicate the reason. Record the pro-rate code.

    - **ROT** tree core is rotten
    - **CRC** cannot reach center with increment borer

12.6 Ongoing Measurement Procedures for the Large Tree Plot

Large Tree Plot

Plot Establishment

1. Establish the Large Tree Plot boundary using the same procedures used in establishment.

2. Measure borderline trees to determine if any trees were missed in the original measurement or ingrowth trees are present since establishment

3. Divide the plot into sectors as per the procedures used in sample establishment.

Large Tree Number

1. Each large tree was assigned a number during establishment and will retain that number for successive measurements. Assign a unique new number to any trees that were not numbered on establishment. Tag these trees in the same pattern as the original establishment procedures. For all existing tagged trees:

    - Pull the tags out from the stem to allow for growth expansion over the next measurement cycle.

    - If a tag is missing or damaged, replace the tag. If you can read the damaged tag, or can determine the tree number without the tag, then the tree should be tagged with the same number used in the previous measurement. If unable to determine what the tree number was, tag the tree with a unique new number within the plot and note the change of number in the comments section.

    - If tree tags are obviously visible, move the tags to where they are substantially hidden. These plots are measuring change and should not be overly visible where they might be treated differently than a normal forest stand.

Large Tree Details

Measure the details on all large trees within the plot.

1. Complete the header information
2. Measure, record, and confirm the following attributes:

    - sector
    - tree number
    - tree genus
    - tree species
    - tree variety
    - large tree status
    - dbh
    - measured/estimated dbh
    - tree height
    - measured/estimated height
    - crown class
    - height to live crown base and top
    - tree condition codes

- azimuth to tree (as required)
- distance to tree (as required)
- damage agents, location, and severity.

3. Stem mapping of plot center pin: Confirm stem map details and refresh nails, as required. If not completed on original sample, complete stem mapping.

Trees Removed from the Large Tree List since the Last Measurement Cycle

Large trees measured in the previous measurement cycle that no longer meet the definition of a large tree at the time of remeasurement should not be remeasured as large trees. If trees are removed from the list, please complete the "Removed Trees" section of the **Large Tree Card (Card 10)**.

1. **Tree Number:** List, by tree number, each tree that is being removed from the large tree list.
2. **Reason:** Using the codes below, record the reason each tree is being dropped from the list:
    - **C:** Tree cut below the 1.3-m mark.
    - **B:** Tree broken below the 1.3-m mark.
    - **D:** Tree no longer meets the minimum diameter requirement (e.g., bark has fallen off a dead standing tree).
    - **F:** Tree is now dead fallen (i.e., woody debris).
    - **U:** Tree cannot be found on remeasurement.
    - **O:** Other.

Site Tree Information

Measure and record details on site trees as follows:

- Identify the site trees within the plot using the selection criteria outlined in the guidelines.
- For any selected trees "cored" in a previous measurement, record all required attribute information but do not re-core the tree. Confirm with the project manager which trees have age samples before field visitation.
- For any selected trees "not cored" in a previous measurement, record all required attribute information including taking age cores.
- Record in the comments any site tree selection issues.

13.0 Small Tree, Shrub, and Stump Plot

13.1 Introduction

A 3.99-m fixed-radius plot will be established at all ground plot centers to collect data on small trees, shrubs, and stumps. The plot size is kept small to reduce measurements as many small units may be tallied. A square plot with an equivalent area may be established.

13.2 Objectives

To collect accurate tallies of small trees, shrubs, and stumps to enable the calculation of:

- gross volume (m^3/ha) for live and dead small trees
- gross biomass (mg/ha of oven-dry material) for live and dead small trees
- gross biomass (mg/ha of oven-dry material) for live and dead shrubs
- gross volume (m^3/ha) for stumps
- gross biomass (kg/ha of oven-dry material) for stumps
- various biodiversity indices.

13.3 Definitions

Small Tree: For this inventory, a small tree is a "tree" ≥ 1.3 m in height and < 9.0 cm dbh. Small trees include all live standing, live fallen and dead standing trees.

Shrub: For this inventory, a shrub is a woody perennial plant, typically shorter than most trees, having multiple stems that branch from the base without a well-defined main stem. In this plot, only shrubs ≥ 1.3 m in height will be measured.

Tree Stump: The woody base of a tree that remains after the rest of the tree has fallen due to decay, rot, and felling (Dunster and Dunster 1996). For NFI purposes, stumps must be self-supporting, vegetatively dead or dead with live suckers, and < 1.30 m in height. In this plot, information will only be collected for stumps that have a top diameter inside bark of > 4 cm.

13.4 General Procedures

The procedures within this section are listed as they appear on the field cards but the field crew is free to measure attributes in the most efficient sequence.

1. Establish the plot circumference as required.
2. Complete the header information on the field cards.

3. Collect the attributes for small trees, shrubs, and stumps. These may be done separately or together.

Field Cards for the Small Tree, Shrub, and Stump Plot

Small Tree Information (12) (Appendix B, Diagram 19)
Field card for small trees in the 3.99-m plot: species, tree status, diameter, height, and measure/estimate attribute.

Shrub Information (13) (Appendix B, Diagram 20)
Field card for shrubs in the 3.99-m plot: species, status, basal diameter, height, and frequency.

Stump Plot (14) (Appendix B, Diagram 21)
Field card for stumps in the 3.99-m plot: species, top diameter, top diameter inside bark, length, and decay class.

13.5 Detailed Procedures

Plot Establishment

1. Establish a 3.99-m fixed-radius plot, centered on the ground plot center. A square plot with an equivalent area would have a side length of 7.07 m.

2. Mark the outside of the plot temporarily, as needed, to ensure stems are not missed. Use ribbon, string, or spots of tree marking paint on the ground to delineate the boundaries of the plot. In open conditions, marking may not be necessary.

Measuring Small Tree Attributes

The following "small trees" are measured:

For this inventory, a small tree is a "tree" that is ≥ 1.3 m in length and < 9.0 cm dbh. Small trees include all live standing, live fallen, and dead standing trees.

Points to consider:

- Small trees must have their point of germination within the plot radius to be recorded as "in" trees.

- In some instances, particularly with deciduous species, clumps of stems originating from a common root system, stump, or log that is vegetatively alive are encountered. Some or all of these stems could grow into trees in the future. The sampling intent is to identify the stems expressing apical dominance to the best judgment of the field crew. Count the number of stems that appear to express apical dominance. The intent is not to examine each stem in detail but to arrive at a reasonable assessment of tree numbers.

- The marking of trees with tags or painted numbers is optional to meet the national standard, as individual trees will not be tracked for successive measurements. Some marking of larger stems with numbers may be desirable for immediate quality control. Most crews will mark the measured trees in

dense stands with a paint mark at the base or piece of ribbon to avoid double counting of stems. These are removed at the end of sampling.

- Trees that have been "cut" above 1.3 m are considered small trees for this inventory.
- As there may be many small trees in young stands, a height pole may be useful in measuring tree heights.

Completing the Small Tree Field Card (8a) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.
2. **Measurement Date:** Enter the date of information capture in the field.
3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.
4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.
5. **Nominal Plot Size:** Record the area of the Small Tree Plot to the nearest 0.0001 ha. A circular Small Tree Plot with a radius of 3.99 m will have an area of 0.0050 ha.
6. **Measured Plot Size:** Record the area of the Small Tree Plot to the nearest 0.0001 ha. A circular Small Tree Plot with a radius of 3.99 m will have an area of 0.0050 ha.
7. **Plot Type:** Enter a three-character plot type code:
   - **STC** = **S**mall **T**ree **C**ircular plot
   - **STS** = **S**mall **T**ree **S**quare plot

Completing the Small Tree Field Card (8a) Details

1. **Small Tree Number:** In a clockwise direction from the north, identify and record small trees consecutively in ascending order.
2. **Small Tree Genus:** Record the genus of each small tree using the first four letters of the scientific genus name (see Appendix E).
3. **Small Tree Species:** Record the species of each tree using the first three letters of the scientific species name.
4. **Small Tree Variety:** If applicable, record the variety of each tree using the first three letters of the scientific variety name. This field may be left blank.
5. **Small Tree Status:** Record the status code that best describes the live or dead and standing or fallen condition of the small tree. Note that dead fallen trees are not collected in the Small Tree Plot. Refer to Table 13.1 for definitions.

Table 13.1 Small tree status codes.

Code	Description
LS	Live Standing - Live trees have enough foliage to keep them alive (live cambium is present), are intact, and are rooted into the ground. Lack of foliage for some species, of course, is no indication of death during some seasons. Standing trees are self-supporting (i.e., the tree would remain standing if all supporting materials were removed).
LF	Live Fallen - See previous definition of "live." Fallen live trees are not self-supporting and would not remain standing if all supporting materials were removed.
DS	Dead Standing - Dead trees are obviously (physiologically) dead. They are still self-supporting (rooted into the ground) and would remain standing if all supporting materials were removed (e.g., snags).

6. **Small Tree dbh (cm):** For each tree (live or dead), record the dbh to the nearest 0.1 cm. Acceptable values are from 0.1 to 8.9 cm.

7. **Small Tree Height (m):** Record the height of each tree to the nearest 0.1 m. All heights must be ≥ 1.3 m.

8. **Measured, Calculated, or Estimated Small Tree Height:** Record whether the tree height was measured by field crew (M); estimated by field crew (E); or calculated, usually from height diameter curves (C).

9. **Stem Condition:** Use this field to indicate whether the main stem of the tree is intact (I) or broken (B).

10. **Comments:** Record any unusual features affecting the small trees on the plot such as insect or disease activity, mechanical damage, snowpress, etc.

Measuring Shrub Attributes

All shrubs ≥ 1.3 m in height will be measured in this plot.

Points to consider:

- Shrubs must have their point of germination within the plot radius to be recorded as "in" shrubs.
- Shrubs < 1.3 m in height are not measured in this plot but will be clipped in the microplots.
- The marking of shrubs with tags or painted numbers is optional to meet the national standard as individual shrubs will not be tracked for successive ongoing measurements. Some marking of larger stems with numbers may be desirable for immediate quality control. Most crews will mark the measured shrubs in dense stands with a paint mark at the base or piece of ribbon to avoid double counting of stems. These are removed at the end of sampling.
- As there may be many shrubs in many stands, a height pole may be useful in measuring heights.

Completing the Shrub Plot Field Card (13) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.
2. **Measurement Date:** Enter the date of information capture in the field.
3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.
4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.
5. **Nominal Plot Size:** Record the area of the Shrub Plot to the nearest 0.0001 ha. A circular Shrub Plot with a radius of 3.99 m will have an area of 0.0050 ha.
6. **Measured Plot Size:** Record the area of the Shrub Plot to the nearest 0.0001 ha. A circular Shrub Plot with a radius of 3.99 m will have an area of 0.0050 ha.
7. **Plot Type:** Enter a three-character plot type code:
   - **STC** = **S**mall **T**ree **C**ircular plot
   - **STS** = **S**mall **T**ree **S**quare plot

Completing the Shrub Plot Field Card (13) Details

1. **Shrub Number:** Assign each shrub within the plot a unique number. Shrubs are generally numbered in ascending order in a clockwise direction from the north.
2. **Shrub Genus:** Record the genus of each shrub using the first four letters of the scientific genus name (see provincial vegetation lists).
3. **Shrub Species:** Record the species of each shrub using the first three letters of the scientific species name.
4. **Shrub Variety:** If applicable, record the variety of each shrub using the first three letters of the scientific variety name. This field may be left blank.
5. **Shrub Status:** Record the status code that best describes the shrub; either Live (LV) or Dead Standing (DS).
6. **Basal Diameter Class:** Record the basal diameter class of each shrub. Basal diameter is measured at the ground line or just above the root collar, whichever is higher. Shrubs with basal diameters ≤ 7.5 cm (classes 0–3) can be measured using a go-no-go gauge (same gauge used for measuring small woody debris). Larger shrubs can be measured using calipers or a diameter tape.

Basal diameter class	Basal diameter (cm)
Class 0	0.1–1.0
Class 1	1.1–3.0
Class 2	3.1–5.0
Class 3	5.1–7.5
Class 4	7.6–10.0
Class 5	10.1–12.5
Class 6	12.6–15.0

7. **Height Class:** Assign a height class to each shrub based on the height of the longest stem, measured along the curvature of the stem.

Height class	Height of tallest stem (m)
Class 1	1.3–2.0
Class 2	2.1–3.0
Class 3	3.1–4.0
Class 4	4.1–5.0

8. **Frequency:** When there are multiple occurrences of a shrub species with the same status, basal diameter class, and height class, they may be recorded as a multiple occurrence. If there are no multiple occurrences, frequency = 1.

9. **Comments:** Record any unusual features affecting the shrubs on the plot such as insect or disease activity, mechanical damage, snowpress, etc.

Measuring Stump Attributes

The following "stumps" are measured:

> For NFI purposes, stumps must be self-supporting, vegetatively dead or dead with live suckers, > 1.30 m in length with a top diameter inside bark of ≥ 4 cm.

Points to consider:

- Stumps must have the center of the stump at ground level within the plot radius to be recorded as "in."
- Stumps may be human-made or naturally occurring from stem breakage.
- Stumps that are vegetatively alive (cut/broken) with sucker growth are recorded. In many deciduous stands, the cut stumps remain vegetatively alive and sprout live sucker growth from the partially dead stump. Measure these stumps in the stump plot. Any sucker growth will be measured in the Small Tree Plot or accounted for in the clipped microplots (Figure 13.1).

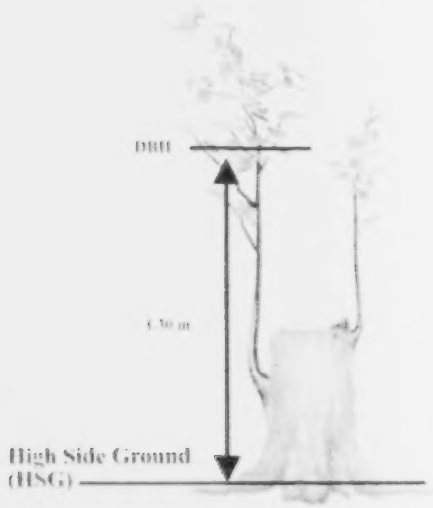


Figure 13.1 Measuring live stumps.

- Overturned tree stumps, with roots detached from the ground, are to be treated as "woody debris" and are not measured in the stump plot.
- To assist quality control, it may be advisable to temporarily number the stumps with paint or ribbon, etc.
- To measure the length of broken stumps, visually fold down the broken sections to compensate for the missing parts (Figure 13.2). Level out the wood on the cross-section as you view it from the side to determine stem length.

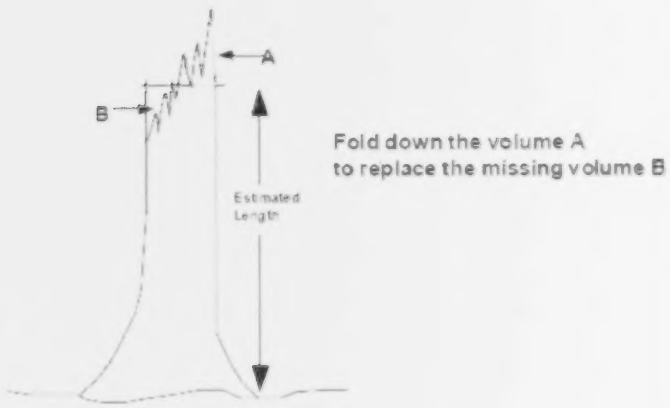


Figure 13.2 Length measurements of broken stumps.

Completing the Stump Plot Card (14) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.
2. **Measurement Date:** Enter the date of information capture in the field.
3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.
4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.
5. **Measured Plot Size (ha):** Record the area of the stump plot to the nearest 0.0001 ha. A circular stump plot with a radius of 3.99 m will have an area of 0.0050 ha.
6. **Nominal Plot Size (ha):** Record the area of the stump plot to the nearest 0.0001 ha. A circular stump plot with a radius of 3.99 m will have an area of 0.0050 ha.
7. **Plot Type:** Enter a three-character plot type code:
   - **STC** = **S**mall **T**ree **C**ircular plot
   - **STS** = **S**mall **T**ree **S**quare plot

Completing the Stump Plot Field Card (14) Details

1. **Stump Number:** In a clockwise direction from the north, identify and number stumps consecutively in ascending order.
2. **Stump Genus:** Record the genus of each stump tree using the first four letters of the scientific genus name (Appendix E).
3. **Stump Species:** Record the species of each stump using the first three letters of the scientific species name.
4. **Stump Variety:** If applicable, record the variety of each stump using the first three letters of the scientific variety name. This field may be left blank.
5. **Stump Top Diameter Inside Bark (cm):** Record the diameter inside bark at the top of the stump to the nearest 0.1 cm.
6. **Stump Top Diameter:** Record the diameter at the top of the stump to the nearest 0.1 cm including bark in the measurement. If there is no bark, the top diameter will be equal the top diameter inside bark.
7. **Stump Length (m):** Record the length of each stump to the nearest 0.01 m.
8. **Decay Class:** Record the average decay class of the stump based on the majority condition of the entire stump. The five classes used are the same ones that are used to describe woody debris with the focus on wood texture (Table 13.2).

Table 13.2 **Woody debris and stump decay class descriptions for NFI reporting.**

	DECAY CLASS				
	1	2	3	4	5
Wood texture	**intact, hard**	**intact, hard to partly decaying**	**hard, large pieces, partly decaying**	**small, blocky pieces**	**many small pieces, soft portions**
Portion on ground	elevated on support points	elevated but sagging slightly	sagging near ground, or broken	all of log on ground, sinking	all of log on ground, partly sunken
Twigs < 3 cm (if originally present)	twigs present	no twigs	no twigs	no twigs	no twigs
Bark	bark intact	intact or partly missing	trace bark	no bark	no bark
Shape	round	round	round	round to oval	oval
Invading roots	none	none	in sapwood	in heartwood	in heartwood

9. **Comments:** Record any unusual features affecting the stumps on the plot such as root rot activity, mechanical damage, tree spacing stumps, etc.

13.6 Ongoing Measurement of the Small Tree, Shrub, and Stump Plot

Ongoing measurement of the Small Tree, Shrub, and Stump Plot at each successive visit will require the re-establishment of the 3.99-m plot and the recording of plot header and plot details as if it was a new plot.

After completion of the measurements, it would be appropriate to refer to the previous measurement data to confirm any data anomalies. In the comments section of the card, document any significant changes from the previous measurements, such as drought conditions have killed many trees and/or shrubs, fire has damaged stems on plot, species identified in last measure were incorrectly coded, etc

14.0 Site Assessment

14.1 Introduction

A site assessment is required for each ground plot to provide a record of conditions at NFI ground plot locations including succession characteristics of the stand, information on site disturbance and a description of the ecosystem.

14.2 Objectives

- To collect the established sample coordinates using GPS.
- To collect site features information.
- To classify the sample plot using the NFI Land Cover Classification Scheme.
- To identify the origin of the tree component on the sample plot.
- To identify any activities or treatments affecting the vegetation component on the sample plot.
- To identify any natural disturbances that have significantly changed the structure and/or composition of the sample plot vegetation.

14.3 General Procedures

1. Collect GPS data for the established sample center.
2. Measure and record site features for the sample plot.
3. Classify the sample using the NFI Land Cover Classification Scheme.
4. Identify and record forest stand structure and succession stage.
5. Identify and record the origin of the trees on the sample plot.
6. Identify and record treatments affecting the vegetation on the plot.
7. Identify and record disturbances and their extent as they affect the overall plot.

Field Cards for Site Assessment

Ground Plot Site Information (15) (Appendix B, Diagram 22)

Field card for Site Assessment: province/territory, UTM Northing, UTM Easting, provincial ecosystem type, slope, aspect, land base, land cover, land position, vegetation type, density class, stand structure, successional stage, elevation, tree origin information, plot treatment information, natural disturbance(s) to the plot.

14.4 Detailed Procedures

Site Assessment

Site information is generally assessed last, when everyone has a thorough knowledge of the site. Disturbance, treatment, and origin information are related to data collected within the boundaries of the Large Tree Plot and should therefore be interpreted within the boundaries of the Large Tree Plot. Other site information does not require a plot with specific boundaries, only an appropriately sized reference area. A circular plot would work well because its boundaries can easily be estimated and round plots have less edge (hence less opportunity for edge trees). To evaluate site feature attributes, it is acceptable to look beyond the radius of the Large Tree Plot to an approximate radius of 25 m around the plot center. This will depend on the attribute, site variability, and topographic features.

Completing the Ground Plot Site Information Card (15) Header Information

1. **Network Label:** Record the NFI label (a value between 1 and 1 600 000) that identifies the point on the network associated with the ground plot.

2. **Measurement Date:** Enter the date of information capture in the field.

3. **Measurement Number:** A newly established plot will have measurement number of 0. The first remeasurement would have a measurement number of 1, etc.

4. **Crew Initials:** Record the initials of the field crew completing the sampling for this particular plot. Person 1 would be the individual responsible for the measurements and persons 2 and 3 (persons 2 and 3 may not be required on some samples) would be the assistants.

5. **Plot Completion:** This field is to keep track of NFI ground plots that could not be measured in full or at all and the reason(s) why.

    a. Record if the NFI ground plot was completed in full (F), in part (P), or not completed (U).

    b. Check the appropriate box on the field card to indicate the reason(s) a plot was not measured in full. For example:

        i. If access was denied, record a "✓" for this attribute.

        ii. If the sample or parts of the sample were too hazardous to access, record a "✓" for this attribute.

        iii. If the sample was only partially completed due to non-forested area in the plot, record a "✓" for this attribute.

        iv. If the plot was "split" in the previous measure, record a "✓" for this attribute.

        v. If there is an "other" reason(s) the plot was not fully completed, record a "✓" for this attribute.

vi. If the plot was measured in full, record a "✓" in the "non applicable" box.

c. In all instances where a full plot was not completed, record the reason in the comments. Also note on the applicable field cards as required.

6. **UTM Northing:** UTM coordinates are used for plot location identification. Using a hand-held GPS, measure and record, to the nearest metre (7 characters), the UTM northing of the center point location of the plot.

7. **UTM Easting:** Using a hand-held GPS, measure and record, to the nearest metre (6 characters), the UTM easting of the center point location of the plot.

8. **UTM Zone:** Record the number (between 7 and 22) that signifies which UTM zone the center point location of the plot is located.

9. **Province/Territory:** This field is used to identify the jurisdiction to which the data apply and to allow data to be summarized by jurisdiction where required. Record the two-letter code describing the province or territory in which the data are collected. Codes for each province and territory are in Table 14.1.

Table 14.1 Province and territory codes for NFI reporting

Province	Code
Alberta	AB
British Columbia	BC
Manitoba	MB
New Brunswick	NB
Newfoundland and Labrador	NL
Northwest Territories	NT
Nova Scotia	NS
Nunavut	NU
Ontario	ON
Prince Edward Island	PE
Quebec	QC
Saskatchewan	SK
Yukon Territory	YT

10. **Terrestrial Ecozone:** Ecozone is an ecological land classification code describing a uniquely classified, ecologically distinctive area in Canada. Each area is viewed as a discrete system that has resulted from interplay of geographic, landform, soil, vegetation, climatic wildlife, water, and human factors that may be present (Wiken 1986). This field is used to identify the terrestrial ecozone to which the data apply and to allow data to be summarized by ecozone. Record the terrestrial ecozone in which the ground plot is located using the codes in Table 14.2.

Table 14.2 Terrestrial ecozone codes for NFI reporting.

Terrestrial Ecozone	Code
Arctic Cordillera	1
Northern Arctic	2
Southern Arctic	3
Taiga Plains	4
Taiga Shield	5
Boreal Shield	6
Atlantic Maritime	7
Mixedwood Plains	8
Boreal Plains	9
Prairies	10
Taiga Cordillera	11
Boreal Cordillera	12
Pacific Maritime	13
Montane Cordillera	14
Hudson Plains	15

11. **Provincial Ecosystem Type:** Using the applicable ecosystem classification for the province the site is in, classify to the site association/site series level. All levels of ecosystem type should be used in the assignment of provincial ecosystem type. An example in British Columbia would be CWHmm2-01 (Coastal Western Hemlock zone, moist maritime subzone, montane variant, HwBa site series).

12. **Provincial Ecosystem Type Reference:** Refers to reference or publication used for ecosystem provincial ecosystem type classification scheme. Number assignment refers to a list of provincial classification manuals (still to be completed).

13. **Slope:** Slope information is important for soil landform classification. Using a clinometer or similar instrument, measure and record the slope gradient to the nearest percent. For uniform conditions, assess slope by averaging over a 100-m distance (50 m above and below the plot center). If there is a major topographic break in the slope, measure only to the break point.

14. **Aspect:** Aspect information is collected for growth modeling. Record the orientation of the downward slope (0 to 359°) using a compass bearing. Level ground (≤ 2% slope) has no aspect; code as 999. If the aspect is "due north," the value is recorded as "0" degrees.

15. **Elevation:** Using a hand-held GPS, record, in metres, the elevation at plot center. Elevation is reported as height above ellipsoid.

16. **Land Base:** A unique, one-letter identifier that signifies the presence or absence of vegetation within the boundaries of the ground plot. Enter the appropriate one-letter land base code based on the descriptions provided for

the *first* level of the NFI Land Cover Classification Scheme (Table 14.2 and Appendix P).

17. **Land Cover:** A unique, one-letter identifier that signifies the presence or absence of trees for vegetated plots, and land or water for non-vegetated plots. Enter the appropriate one-letter land cover code based on the descriptions provided for the *second* level of the NFI Land Cover Classification Scheme (Table 14.2 and Appendix P).

18. **Landscape Position:** A unique, one-letter identifier used to indicate the location of the plot relative to drainage. Enter the appropriate one-letter landscape position code based on the descriptions provided for the *third* level of the NFI Land Cover Classification Scheme (Table 14.2 and Appendix P).

19. **Vegetation Type:** Vegetation type is a unique, two-letter identifier used to signify the distinct type of vegetated or non-vegetated condition of the land base within the plot. For plots where the land cover and land base are unreported, record vegetation type as MI (missing), otherwise record the appropriate two-letter vegetation type code according to the *fourth* level of the NFI Land Cover Classification Scheme (Table 14.2 and Appendix P). Note in comments if vegetation type has changed substantially since the previous measurement cycle.

20. **Density Class:** A unique, two-letter identifier used to indicate the cover of vegetation in vegetated plots, or to further classify non-vegetated plots. Record a two-letter density class code according to the *fifth* level of the NFI Land Cover Classification Scheme (Table 14.3 and Appendix P).

Table 14.3 Land cover condensed version.

Level I – Land Base		
Codes		Description
V		**Vegetated:** Total cover of tree-, shrub-, herb-, and moss-layers (other than crustose lichens) ≥ 5% of the site within the 10 m radius plot.
N		**Non-vegetated:** Total cover of tree-, shrub-, herb-, and moss-layers (other than crustose lichens) < 5% of the site within the 10 m radius plot.
Level II – Land Cover		
Codes		Description
V	T	**Treed**: ≥ 10% of the area is covered in tree species of any size.
	N	**Non-Treed**: < 10% of the area is covered in tree species of any size.
N	L	**Land:** More than half of the area is covered by land (i.e., not covered by water as defined below).
	W	**Water:** More than half of the area is covered by a naturally occurring static water body ≥ 2 m in depth in some portion, or flowing water between continuous definable banks. These flows may be intermittent or perennial; but do not include ephemeral flows where a channel with no definable banks is present. Islands within streams that have definable banks are not part of the stream; gravel bars are part of the stream.
Level III – Landscape Position		
	Codes	Description
V or N	W	**Wetland:** Includes SMR = 7 and wetter. Land having the water table near, at, or above the soil surface, or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by poorly drained soils, specialized vegetation, and various kinds of biological activity which are adapted to the wet environment.
	U	**Upland:** Includes everything between wetland and alpine; SMR ranges from 0 to 6.
	A	**Alpine:** Treeless by definition (for practical purposes < 1% tree cover can be included) with vegetation dominated by shrubs, herbs, graminoids, bryoids and lichens. Much of the alpine is covered by primarily rock, ice, and snow.
Level IV – Vegetation Type		
V	TB	**Treed Broadleaf:** Total cover of broadleaf trees ≥ 75% of the total tree cover, and tree cover ≥ 10%.
	TC	**Treed Coniferous:** Total cover of coniferous trees ≥ 75% of the total tree cover, and tree cover ≥ 10%.
	TM	**Treed Mixed:** Neither coniferous nor broadleaf trees cover ≥ 75% of the total tree cover, and tree cover ≥ 10%.
	ST	**Shrub Tall:** Shrub site with average shrub height ≥ 2 m.
	SL	**Shrub Low:** Shrub site with average shrub height < 2 m.
	HE	**Herb:** Herb site with no distinction between forbs and graminoids.
	HF	**Herb - Forbs:** Herb site with forbs (non-graminoid) > 50% of the herb cover.
	HG	**Herb - Graminoids:** Herb site with graminoids (grasses, sedges, and rushes) > 50% of herb cover.
	BY	**Bryoid:** Bryoid site with no distinction between mosses, liverworts, hornworts, and lichens.
	BM	**Bryoid - Moss (bryophytes):** Bryoid site with mosses, liverworts, and hornworts forming > 50% of the bryoid cover.
	BL	**Bryoid - Lichens:** Bryoid site with lichens (not crustose) forming > 50% of the bryoid cover.
N	SI	**Snow / Ice:** Permanent snow or ice.
	RO	**Rock / Rubble:** Bedrock or fragmented rock moved to present position by gravity or ice.
	EL	**Exposed Land:** All other forms of exposed land.

Level V – Density (Vegetated) and Land types (Non-vegetated)					
	Code	Description		Code	Description
V	DE	**Dense**: Tree, shrub or herb cover 61–100%	N	LL	**Landing**
	OP	**Open:** Tree, shrub or herb cover 26–60%, or bryoids ≤ 50%		BU	**Burned Area**
	SP	**Sparse:** Treed cover 10–25%, and shrub and herb cover < 26%		RZ	**Road Surface**
	CL	**Bryoid polygon-Closed:** Bryoid site, with bryoid cover > 50%		MU	**Mudflat Sediment**
	OP	**Bryoid polygon- Open:** Bryoid site, with bryoid ≤ 50%			
N	GL	**Glacier**		CB	**Cutbank**
	PN	**Snow Cover**		MN	**Moraine**
	BR	**Bedrock**		GP	**Gravel Pit**
	TA	**Talus**		TZ	**Tailings**
	BI	**Blockfield**		RN	**Railway**
	MZ	**Rubbly Mine Spoils**		UR	**Urban**
	LB	**Lava Bed**		OT	**Other**
	RS	**River Sediments**		LA	**Lake**
	ES	**Exposed Soil**		RE	**Reservoir**
	LS	**Pond or Lake Sediments**		RI	**River/Stream**
	RM	**Reservoir Margin**		OC	**Ocean**

Stand Structure: The structure of the prevailing forest cover in the plot, if treed, and is based on the vertical structure of the stand. Stand structure information is used with vegetation age and successional stage to determine whether the ground plot has old-growth characteristics. Record the applicable stand structure code from the choices below:

SNGL	Single storied
MULT	Two or more distinct canopy layers
COMP	Complex, non-distinct layers
NA	Non-applicable (non-treed)

21. **Successional Stage:** A series of dynamic changes in ecosystem structure, function, and species composition over time as a result of which one group of organisms succeeds another through stages leading to a potential natural community or climax stage (Dunster and Dunster 1996).

    For this inventory, the successional stage represents a snapshot in time of the vegetation dynamics occurring in the plot. In complex sites, focus on the *majority* of the site. To interpret succession, it may be necessary to look beyond the boundaries of the plot.

    Record the two-letter code that best describes the successional stage of the majority condition of the plot using the descriptions provided in Table 14.4.

Table 14.4 Successional stage codes (Dunster and Dunster 1996).

Succession stage	Code	Description
Early Seral	**ES**	The period from disturbance to crown closure of conifer stands managed under the current forest management regime. • Grass, herbs, or brush are abundant. • A period of high diversity, often suitable for a broad group of plants and animals.
Mid-Seral	**MS**	The period in the life of a forest stand from crown closure to first merchantability, usually ages 15–40 years. • Due to stand density, brush, grass, or herbs rapidly decrease in the stand. • Hiding cover may be present. • A period of declining diversity, suitable for a narrower group of plants and animals.
Late Seral	**LS**	The period in the life of a forest stand from first merchantability to culmination and mean annual increment (MAI). • During this period, stand diversity is minimal, except that conifer mortality rates will be fairly rapid. • Hiding and thermal cover may be present. • Forage is minimal.
Mature Seral	**TS**	The period in the life of the forest stand from culmination of MAI to an old-growth stage. • This is a time of gradually increasing stand diversity. • Hiding and thermal cover, and some forage may be present.
Old Growth Seral	**OG**	• Represents the potential plant community capable of existing on a site and is determined by the frequency of natural disturbance events. • This final stage continues until stand replacement occurs and the secondary succession process starts again. • In forests where there are long periods between natural disturbance events, the overall forest structure will tend to be more even-aged than forest types undergoing more frequent disturbances.

22. **Wetland Class:** A wetland is "land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity which are adapted to a wet environment" (National Wetlands Working Group 1988). Five different wetland classes are recognized in Canada: bog, fen, swamp, marsh, and shallow water (National Wetlands Working Group 1997). At each ground sample plot, classify the majority of the area using the descriptions in table 14.5.

Table 14.5 Wetland class codes.

Wetland code	Wetland class	Description
B	Bog	• Accumulated peat • Most frequently dominated by *Sphagnum* mosses, with tree, shrub or treeless vegetation cover • Water table at or slightly below the surface and wetland raised above the surrounding terrain
F	Fen	• Accumlated peat • Peat materials derived primarily from sedges with inclusions of partially decayed stems of shrubs formed • Graminoids and shrubs characterize the vegetation cover • Fluctuating water table that may be at, or a few centimetres above or below, the surface
S	Swamp	• Mineral wetland with highly decomposed woody peat and organic material • Coniferous or deciduous trees, or shrub vegetation cover • Water table at or below the surface
M	Marsh	• Mineral wetland with little accumulation of organic material and peat or aquatic plants • Emergent aquatic plants include rushes, grasses, sedges, and some floating aquatics • Shallow surface water that fluctuates dramatically
W	Shallow Water	• Contain standing or flowing water < 2 m deep in mid-summer • Transitional area between wetlands and permanent deep water bodies (i.e., lakes) • Usually contain limnic peat • May dry intermittently in semi-arid regions, leaving evaporate alkaline salt deposits • May be bordered by rooted emergent vegetation (< 25% of wetland area); may also contain rooted submerged and floating aquatic vegetation, algae, and aquatic mosses
N	Non-Wetland	• Non-wetland, terrestrial system (upland)

Note: Definitions based on the Canadian Wetland Classification System (National Wetlands Working Group 1997).

23. **User Information/Comments:** Record any user information or comments on measurements in the plot. This is a good place to record the accuracy of the GPS unit used (as determined from the unit specifications).

Completing the Ground Plot Site Information Card (15) Tree Cover Origin Information

1. **Tree Cover Origin(s):** Plot tree origin data are important for regeneration studies and growth projection modeling, and may be used to predict successional trends. Using the codes listed in Table 14.6, record the origin of the tree cover in the plot. Many tree cover origins may be present in the plot at the same time. For example, secondary succession may be present in addition to regeneration after harvest. Enter a separate record for each origin type in the plot, including the associated regeneration type and year.

Table 14.6 Tree cover origin codes for NFI reporting.

Code	Tree cover origin
SUCC	Establishment of trees through secondary **succession**
HARV	Regeneration after **harvest**
DIST	Regeneration after a **disturbance** other than harvesting
AFOR	Establishment of trees on an area that has either been lacking in forest cover for some time or has never been forested
UNK	Origin of tree cover is **unknown**
NA	Not applicable as site is not treed at this time

2. **Regeneration Type:** Using the codes listed in Table 14.7, record the three-letter code that describes the natural or artificial method used in the renewal of trees within the ground plot (e.g., the establishment of new, young trees).

Table 14.7 Regeneration type codes for NFI reporting.

Code	Regeneration type
NAT	Natural regeneration
SUP	Natural regeneration with supplementary planting (planting < 50% of the area)
PLA	Planted regeneration > 50% of area
SOW	Seeded regeneration
NA	Not treed at this time

3. **Regeneration Year:** Estimate the year of regeneration (YYYY). Must be related to tree cover origin. If the site is not treed, code as "-9" (not applicable).

Completing the Ground Plot Site Information Card (15) Plot Treatment Information

For the inventory, treatments are activities applied to the plot or the trees within the plot that directly or indirectly affect the growth of trees on the plot (e.g., prescribed burning, herbicide, mechanical site preparation, cleaning, brushing, and weeding, harvesting). Treatments affecting the growth of trees on the plot are important for growth projection modeling as well as for tree improvement studies.

1. **Treatment Type:** Indicate any treatments applied to the plot by entering the applicable two-letter treatment code (s) using the codes listed in Table 14.8.

Table 14.8 Plot tree treatment type codes for NFI reporting.

Treatment type	Code	Treatment description
Clear-cut	CC	> 80% (by crown area) of the previous forest cover has been removed
Partial-cut	PC	< 80% (by crown area) of the previous forest cover has been removed
Deforestation	DC	The long-term removal of trees from a forested site to permit other site uses. *Note*: The cutting of trees followed by regeneration is not deforestation.
Cleaning	CL	Includes brushing, weeding, herbicide
Juvenile Spacing	JS	The retention of trees at fixed intervals with all the other trees being cut down
Pruning	PR	Pruning
Pre-Commercial Thinning	PT	A silvicultural treatment to reduce the number of trees in young stands (improve spacing), carried out before the stems are large enough to be used or sold as a forest product. The intent is to concentrate growth per unit area on fewer stems, thus increasing mean stand diameter, retaining more live crown, and creating opportunities for commercial thinning, accelerating stand operability, and improving wildlife habitat.
Commercial Thinning	CT	A partial cut in older, immature stands, where trees have reached merchantable size and value, to provide interim harvest while maintaining a high rate of growth on well-spaced, final crop trees
Fertilization	FT	Fertilization
Site Preparation	SP	Site preparation (mechanical/chemical)
Prescribed Burning	PB	Prescribed burning
Herbicide	HC	Herbicide
Other	OT	Other
None	NO	No treatment observed

2. **Treatment Year:** An estimate of the year of the treatment and can be determined using historical or management records. Record a four-digit treatment year for *each* treatment type recorded for a plot. If no treatment was observed, code as "-9" (not applicable).

3. **Treatment Extent (%):** A percentage of the total ground plot area where a treatment has been applied. Record treatment extent for each treatment type. . If no treatment was observed, record "0" for treatment extent.

Completing the Ground Plot Site Information Card (15) Disturbance Information

For this inventory, a natural disturbance agent is described as a naturally occurring discrete force that has disrupted the structure and/or composition of the vegetation in the plot. In other words, the normal growth pattern and/or structure of the vegetation component is altered. Disturbance information is important in assessing site conditions for calculating total ecosystem carbon (e.g., if the plot experienced a burn, the amount of carbon left on the site can be estimated), and is useful in forest health and biodiversity studies, as well as habitat assessments.

1. **Natural Disturbance Agents to the Plot Vegetation:** Record the natural disturbance agent(s) to the plot vegetation observed in the field (up to 12 characters). Disturbance does not have to be at the tree level (e.g., a flood or fire), but generally trees are used as clues. Examples of common disturbance agents are listed in Table 14.9.

Table 14.9 Natural disturbance agents to the Plot Vegetation for NFI reporting.

Disturbance agent	Description
Fire	Plot has experienced a fire.
Wind	Trees in plot have experienced windthrow.
Snow	Trees in plot have experienced significant snow damage.
Insect	Trees in plot have experienced insect attack. *Note*: It can take several years of defoliation to permanently damage the vegetation. The threshold for significant defoliation varies with the type of pest.
Disease	Trees in plot have experienced a disease outbreak.
Erosion	The wearing away of soil by any natural process that causes a removal of tree cover over a large portion of the plot.
Ice	Trees in plot have experienced ice damage.
Other	Plot has experienced other disturbances. The code, "Other" can be replaced by a word that better describes the type of disturbance agent (e.g., "Flooding").
Unknown	Site disturbance is present but the cause is unknown.
None	No disturbance is observed.

2. **Disturbance Year:** Estimate and record the year associated with each disturbance recorded (YYYY). The disturbance year must be related to the disturbance agent and may be obtained by consulting historical management records. If no disturbance is observed, record disturbance year as "-9" (not applicable).

3. **Extent of Disturbance (%):** Disturbance extent is expressed as a percentage of the total ground plot area affected by disturbance. Record the

extent of disturbance for each disturbance type recorded. If no disturbance is observed, record "0" for extent of disturbance.

4. **Extent of Tree Mortality (%):** Record the percentage of the trees within the plot that have experienced mortality as a result of the disturbance (e.g., 50% of the stems in the plot were damaged by fire and are now dead). If a noticeable disturbance is present in the plot, but there are no dead trees, record a 0 in this field. If no disturbance is observed, record "0" for extent of tree mortality.

5. **Mortality Basis:** A qualifier that describes what the "extent of tree mortality" was based on. In the example given above, the extent of mortality was based on the number of stems affected; in this case a code of ST would be recorded for mortality basis. From the list of two-letter codes provided in Table 14.10, record mortality basis.

Table 14.10 Mortality basis codes for NFI reporting.

Codes	Mortality basis
VL	Volume
BA	Basal area
CA	Crown area
ST	Stem numbers
AR	Area
NA	Not Applicable (e.g., there were no trees in the plot, no trees killed in the disturbance, or no disturbance in the plot).

6. **Comments on Natural Disturbance Agents:** This field is for elaborative comments on notable disturbance events that have affected the plot. Record a specific disturbance agent or comment related to the specific disturbance agent, up to 100 characters long. Examples of typical comments that might be entered in this field include the name of the specific disturbance agent (e.g., "ARMILLARIA", "SPRUCE BUDWORM") or a number of specific erosion agents including:

- natural erosion caused by soil instability
- erosion caused by surface water runoff
- erosion caused by avalanche
- erosion caused by harvesting operations (including roads)
- erosion caused by heavy equipment traffic
- erosion caused by road construction (other than harvest roads)
- erosion caused by mining

- erosion caused by forest fire
- erosion caused by wind
- other cause of erosion
- cause of erosion not known.

14.5 Ongoing Measurement for Site Assessment

The primary objectives of the ongoing measurement are to:

- confirm the initial ground plot site information, and
- record any changes from the time of the installation of the original sample plot to the time of ongoing measurement.

Measurement procedures include:

- record the plot header information;
- record the provincial ecosystem type and reference;
- collect and record new UTM coordinates for the plot center pin location;
- collect and record the land classification codes for the plot. Note significant changes from the last measurement in the comments and the cause(s) if known;
- collect and record the stand structure and successional stage;
- confirm tree origin information as provided and record any changes since last measurement;
- confirm plot treatment information as provided and record any treatments since last measurement;
- confirm natural disturbance agents to the vegetation component as provided and record any changes since last measurement; and
- confirm user information and disturbances to the plot as provided and record comments on any measurement item.

15.0 References

Agriculture Canada Expert Committee on Soil Surveys. 1983. The Canada soil information system (CanSIS) manual for describing soils in the field. 1982 Rev. Agriculture Can., Ottawa, ON. 164 p.

Alaback, P.B. 1986. Biomass regression equations for the understory plants in coastal Alaska: Effects of species and sampling design on estimates. Oregon State Univ., Dep. For. Sci., Corvallis, OR. Northwest Sci. 60: 2.

Blake, G.R.; Hartage, K.H. 1986. Bulk density. Pages 363–375 *in* A. Klute, ed. Methods of soil analysis. Part 1. Physical and mineralogical methods. ASA Madison, WI. Agronomy No. 9.

Bonnor, G.M. 1996. The Fraser TSA Pilot Study: A test of the grid inventory. Report prepared for BC Min. For., Resource Inventory Branch, Victoria, BC. 24 p.

Brack, C. 1999. Stand height for forest measurement and modeling. Australian National Univ., Dep. For. <http://sres-associated.anu.edu.au/mensuration/s_height.htm>.

(BCMELP/BCMOF) British Columbia Ministry of Environment, Lands, and Parks and BC Ministry of Forests. 1998. Field manual for describing terrestrial ecosystems. Res. Branch, Victoria, BC. Land Manage. Handb. No. 25.

(BCMOF) British Columbia Ministry of Forests. 2007. Vegetation resources inventory ground sampling procedures. Version 4.7 - July 2007. Resource Inventory Branch, Victoria, BC. <http://www.for.gov.bc.ca/hts/vri/standards/index.html#vri>.

(BCMSRM) BC Ministry of Sustainable Resource Management. 2005. National Forest Inventory – British Columbia. Change monitoring procedures for provincial and national reporting. Version 1.4. Resources Inventory Committee, Victoria, BC.

Dunster, J.; Dunster, K. 1996. Dictionary of natural resource management. Univ. BC Press, Vancouver, BC. 363 p.

Ecological Stratification Working Group. 1994. Terrestrial ecozones and ecoregions of Canada. Agriculture and Agri-Food Canada, Research Branch, Center for Land and Biological Resources Research and Environment Canada. State of the Environment Directorate, Ottawa/Hull, QC. 1:7 500 000 scale map.

(FAO) Food and Agriculture Organization, United Nations. 2001. Global forest resources assessment 2000. Main report. Rome, Italy. FAO Forestry Paper No. 140.

Helms, J. 1998. The dictionary of forestry. Society of American Foresters, Bethesda, MD. 210 p.

Howes, D.E.; Kenk, E., eds. 1997. Terrain classification system for British Columbia. Version 2.0. BC Min. Environ., Lands and Parks, Victoria, BC.

Iles, K. 2003. A samples of inventory topics. Friesens Canada. 869 p.

Kalra, Y.P.; Maynard, D.G. 1991. Methods manual for forest soil and plant analysis. Nor. For. Cen., Edmonton, AB. Info. Rep. NOR-X-319. 116 p.

National Wetlands Working Group. 1988. Wetlands of Canada. Environ. Can., Sustainable Development Branch, Ottawa, ON, and Polyscience Publications Inc., Montreal, QC. Ecological Land Classification Series No. 24. 452 p.

National Wetlands Working Group. 1997. The Canadian wetland classification system. 2nd ed. B.G. Warner and C.D.A. Rubec, eds. Wetlands Research Centre, Univ. Waterloo, Waterloo, ON. 68 p.

Natural Resources Canada. 1999. A plot-based national forest inventory design for Canada. Internal Document. Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, 70 pp.

(OCSRE) Ontario Centre for Soil Resource Evaluation. 1993. Field manual for describing soils in Ontario, 4th ed. Guelph, ON. Publication No. 193-1.

Page-Dumroese, D.S.; Jurgensen, M.F.; Brown, R.E.; Mroz, G.D. 1999. Comparison of methods for determining bulk densities of rocky forest soils. Soil. Sci. Soc. Am. J. 63:379–383.

Parks Canada. 2002. <http://parkscanada.pch.gc.ca/natress/inf_pa1/ECO_DES/ECOZONES/ZONE_00E.HTM>.

Shields, J.A.; Tarnocai, C.; Valentine, K.W.G.; MacDonald, K.B. 1991. Soil landscapes of Canada: Procedures manual and user's handbook. Agric. Can., Land Resour. Res. Centre, Ottawa, ON. Publ. 1868/E.

Soil Classification Working Group. 1998. The Canadian system of soil classification. 3rd ed. Agriculture and Agri-Food Can., Ottawa, ON. Publication 1646. 187 p.

(USDA) U.S. Department of Agriculture, Forest Service. 2002. Forest Inventory and Analysis national core field guide. Vol. 1: Field data collection procedures for phase 2 plots. Version 1.6.

(USDA) U.S. Department of Agriculture, Forest Service, 2005. Forest Inventory and Analysis national core field guide, Vol II: Field data collection procedures for phase 3 indicators, version 3.0.

Wiken, E., comp. 1986. Terrestrial ecozones of Canada. Ecological Land Classification Series No. 19. Hull, QC: Environment Canada.

Zoltai, S.C. 1978. A portable sampler for perennially frozen stone-free soils. Can. J. Soil Sci. 58:521–523.

Appendix A: Glossary of Terms

Afforestation: The establishment of trees on an area that has lacked forest cover for some time or has never been forested.

Age: Years since germination, years since establishment, or years since achieving 1.3 m in height. Typically reported in years (Dunster and Dunster 1996).

Age class: The classification of stands in a forest, or trees in a stand, into a series of ages (e.g., 0–20, 21–40, 41–60, if using 20-year age classes). Certain age classes would equate to certain points in the average stage of tree, stand, or forest development (Dunster and Dunster 1996).

Area available for timber production: Forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the wood supply (FAO 2001).

Azimuth: The horizontal angle or bearing of a point measured from the true (astronomic) north (Dunster and Dunster 1996). Used to refer to a compass on which the movable dial (used to read direction) is numbered in 360°.

Basal area per hectare: The area of the cross-section of tree stems near their base, generally at breast height and including bark, measured over 1 ha of land (Dunster and Dunster 1996). For this inventory, the cross-sectional area (m^2) of all living trees ≥ 9.0 cm dbh, expressed as a per hectare value for the entire plot.

Biomass: The mass of trees and other plant material (kg of oven-dry material) per unit of space (ha) (Dunster and Dunster 1996).

Bryoids: For this inventory, bryoids include mosses, liverworts, hornworts, and non-crustose lichens.

Canopy: The forest cover of branches and foliage formed by tree crowns (Helms 1998).

Clearcut: An area of forest land from which all merchantable trees have recently been harvested (Helms 1998).

Clinometer: A simple instrument for measuring vertical angles of slopes (elevations or depressions) (Helms 1998). In forestry, used to measure distance and tree heights, tilt angle of coarse woody debris.

Coarse fragments: Percent of the total volume of soil material occupied by mineral particles > 2 mm in diameter recorded for each mineral soil horizon.

Coarse woody debris: Dead woody material located above the soil, in various stages of decomposition. The woody debris must be > 7.5 cm in diameter (or equivalent cross-section) at the crossing point, and not self-supporting. Trees and stumps (intact in ground) are considering self-supporting.

Conk: A hard, fruiting body containing spores of a wood-decaying fungus (Dunster and Dunster 1996).

Crown: The live branches and foliage of a tree (Dunster and Dunster 1996).

Crown classes:

Dominant (D): Trees with crowns that extend above the general level of the crown canopy (may include trees, shrubs, or other obstructions) immediately around the measured trees. They are somewhat taller than the co-dominant trees, and have well-developed crowns, which may be somewhat crowded on the sides, receiving full light from above and partly from the side.

Co-dominant (C): Trees with crowns forming the general level of the crown canopy (may include trees, shrubs, or other obstructions) immediately around the measured trees. The crown is generally smaller than those of the dominant trees and is usually more crowded on the sides, receiving full light from above and little from the sides.

Intermediate (I): Trees with crowns below, but extending into, the general level of the crown canopy (may include trees, shrubs, or other obstructions) immediately around the measured trees. The crowns are usually small and crowded on the sides, receiving little direct light from above but none from the sides.

Suppressed (S): Trees with crowns entirely below the general level of the crown canopy (may include trees, shrubs, or other obstructions) around the measured trees, receiving no direct light either from above or from the sides (BC Ministry of Forests 2007).

Crown closure: The percentage of ground covered by the vertically projected crowns of shrubs or trees (Dunster and Dunster 1996).

Cryptobiotic soil: A fragile and complex mix of lichen, moss, liverworts, algae, fungi, and cyanobacteria that colonize the soil surface in semiarid environments.

Dead tree: Trees that are obviously dead or roots separated from the ground and expected to die very shortly.

Declination (magnetic): The angle between the true (geographic) north and magnetic north (direction of the compass needle). Declination varies from place to place and can be "set" on a compass for a particular location (Dunster and Dunster 1996).

Deep organic soil: Organic matter > 40 cm in depth.

Deforestation: Permanent removal of forest cover and withdrawal of land from forest use, for another long-term use. Clear cutting, if shortly followed by reforestation for forestry purposes, is not deforestation (CCFM 1997).

Density class: Fifth level of Land Cover Classification Scheme. Vegetation densities for vegetated plots and a further classification of non-vegetated plots.

Depth to soil features: Observed depth in centimetres to soil features.

Diameter at breast height (dbh): The stem diameter outside bark of a tree measured at breast height, 1.3 m above the ground (Dunster and Dunster 1996) measured from high side.

Diameter inside bark (DIB): The diameter of a tree or log excluding bark thickness.

Diameter tape: A graduated tape based on the relationship of circumference to diameter, which provides a direct measure of tree diameter when stretched around the outside of the tree (Dunster and Dunster 1996), usually at breast height.

Disturbance: A discrete force that has significantly changed structure and/or composition of the forest (Dunster and Dunster 1996).

Exotic (introduced) tree species: Tree species occurring outside their natural vegetation zone, area, or region (FAO 2001).

Fallen trees: Trees that are not self-supporting.

Family: The fourth level of soil classification.

Fine woody debris (FWD): For this inventory, dead woody material located above the litter layer, in various stages of decomposition. Fine woody debris must be ≤ 1.0 cm in diameter (or equivalent cross-section) and not self-supporting. It includes twigs, cones, bark, and wood chunks < 1.0 cm in diameter.

Foliar cover: The percentage of ground covered by the vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded. Foliar cover is always less than canopy cover; either may exceed 100% (SRM 1989).

Forage: Grasses, herbs, and small shrubs that can be used as feed for livestock or wildlife.

Forage production: The weight of forage that is produced within a designated period of time on a given area. The weight may be expressed as either green, air-dry, or oven-dry. The term may also be modified as to time of production such as annual, current year's, or seasonal forage production (SRM 1989). Production can also be expressed as animal unit months (AUMs), which is the amount of dry forage required by one animal unit for one month based on a forage allowance of 26 pounds (11.7 kg) per day.

Forbs: Any broadleaf herbaceous plants except Gramineae (or Poaceae), Cyperaceae, and Juncaceae families (SRM 1989) and, for forage measurement purposes, include ferns and fern allies, club mosses, and horsetails.

A herbaceous plant with broad leaves, excluding the grasses and grass-like plants (e.g., buttercup, sunflower) (Dunster and Dunster 1996).

Forest area: Land ≥ 10% occupied (by crown cover) by tree species of any size, including young natural stands and all plantations that have yet to reach the minimum crown density. Temporarily non-stocked areas (recent harvests) expected to revert to forests (as defined) are included. The land should be > 0.5 ha and > 20 m. The trees must be capable of reaching a mature height of 5 m (FAO 2001).

Forest-dependent species: Species that cannot complete a full life cycle outside the forest. In a forest inventory, the species to consider are the florist elements (trees, shrubs, grasses, flowers, ferns, mosses, lichens).

Forest floor: The entire thickness of organic material overlying the mineral soil or bedrock, consisting of the litter and humus (LFH layers).

Forest structure: The structure of the prevailing forest cover in the plot (if treed) (Helms 1998). Can be single storied, have two or more distinct canopy layers, or have complex, non-distinct multiple layers.

Forest type: A group of forested areas or stands of similar composition, which differentiates it from other such groups. Examples are softwood, mixedwood, and hardwood (Lowe et al. 1994).

Forest undisturbed by man: "Forest land on which there has been no human-caused disturbance that resulted in a depletion" (UNECE/FAO 2000). Forest land that shows natural forest dynamics, such as natural tree competition, occurrence of dead wood debris, natural age structure, and natural regeneration processes. The area of which is large enough to maintain its natural characteristics on its own. Human intervention has

been insignificant, or was long enough ago to have allowed the natural species composition and processes to become established (FAO 2001).

Geographic information system (GIS): A computer system designed to allow users to collect, manage, and analyze large volumes of spatially referenced information and associated attribute data (Dunster and Dunster 1996).

Graminoids: Grass or grass-like plants (sedges and rushes) such as *Poa*, *Carex*, and *Juncus* species (SRM 1989).

Grass: Plants in the family Gramineae, whose characteristics include stems that are jointed at nodes, are hollow (culms), have sheathing leaves, and inflorescences surrounded by glumes. Grass roots may be fibrous, rhizomatous, or stoloniferous. Many grasses have basal meristems, unlike other plants, which have apical meristems (Dunster and Dunster 1996).

Herb: A vascular plant without a woody stem; includes forbs (including ferns and fern allies) and graminoid (grasses, sedges, and rushes) species. The herb layer may include some low woody plants (see provincial plant lists).

Horizon depth: Average distance from "zero depth" (in centimetres) for each horizon in the profile.

Humus form: Form of the organic and organic-enriched mineral horizons at the soil surface (Dunster and Dunster 1996).

Increment (volume growth): Current growth (annual): volume increment on all living trees in a forest during one year (trees alive at the beginning and the end of the year in question). Mean annual increment (MAI): the average annual accrual of total volume on live trees (at measurement) since stand establishment (Dunster and Dunster 1996).

Land base: Second level of the Land Cover Classification Scheme. Presence or absence of vegetation within the boundaries of the plot.

Land cover: Third level of the Land Cover Classification Scheme. Presence or absence of trees for vegetated plots; land or water for non-vegetated plots.

Landscape position: Fourth level of Land Cover Classification Scheme. Location of the plot relative to drainage.

Large tree: For this inventory, a "tree" that is ≥ 1.3 m in height and ≥ 9.0 cm dbh. Large trees include all live standing, live fallen, and dead standing trees.

Leading species: The tree species with the largest basal area per hectare based on all living trees ≥ 9.0 cm dbh. Residual trees from a previous stand are not included in the tally (MSRM 2003).

Leading species criteria: Quantitative criteria used to rank species occurrence.

Leading species percent: Percentage of each species in the plot determined by quantitative criteria used to rank species occurrence.

Litter: Undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs).

Live tree: Trees that have enough foliage to keep them alive (live cambium is present), and are rooted into the ground. Lack of foliage for some species, of course, is no indication of death during some seasons.

Lorey's mean height: This measurement weights the contribution of trees to the stand height by their basal area; it is calculated by multiplying the tree height (h) by its basal area (g), and then dividing the sum of this calculation by the total stand basal area (Brack 1999).

Merchantable volume: The amount of sound wood in a single tree or stand that is suitable for marketing under given economic conditions (BC Ministry of Forests 2003).

Mineral soil: A soil consisting predominantly of inorganic material (e.g., sands, silts, and clays). Mineral material contains ≤ 17% organic carbon (≤ 30% organic matter) by weight. This soil is commonly found underneath organic materials. The type and amount of mineral material depend on the source of the material, route of deposition, meso/microclimate, and mineralogy.

Mortality: Death or destruction of forest trees as a result of competition, disease, insect damage, drought, wind, fire, and other factors, excluding harvesting (CFIC 1988).

Native (indigenous) tree species: Tree species that have evolved in the same area, region, or biotope where the forest stand is growing and are adapted to the specific ecological conditions predominant at the time of the establishment of the stand (FAO 2001).

Network label: The National Forest Inventory label that identifies the point on the network associated with the sample plot.

Nonvascular: Lacking vascular tissue (including xylem and phloem). Nonvascular plants include algae, lichens, mosses, liverworts, as well as the fungi. Because they do not generally have the structural support conferred by vascular tissue, nonvascular plants are essentially non-woody, small and low-growing (Dunster and Dunster 1996).

Old growth: A forest that contains live and dead trees of various sizes, species, composition, and age class structure. Old-growth forests, as part of a slowly changing but dynamic ecosystem, include climax forests but not subclimax or mid-seral forests. The age and structure of old growth varies significantly by forest type and from one region to another (Dunster and Dunster 1996).

Organic matter: Non-living material derived from living organisms. Includes needles, leaf litter, and partially decomposed organic material.

Organic soil: A soil containing a high proportion of organic matter. They contain > 17% organic carbon (≥ 30% organic material) by weight. These soils are often common in wetland areas such as bogs, marshes, and swamps, or found on top of restrictive layers such as permafrost. Organic soils are soils with > 60 cm of organic material (if surfaces horizons are Of_), or > 40 cm of organic material (if surface horizons are Om_ or Oh_), or > 10 cm if they overlie rock (Canadian System of Soil Classification 1998).

Peat: An accumulation of partially decomposed plant material deposited under saturated soil conditions.

Phenology: The study of periodic biological phenomena that are recurrent, such as flowering or seeding, especially as related to climate (SRM 1989).

Polygon: A stream of digitized points approximating the delineation (perimeter) of an area (forest type) on a map. Polygons often are comprised of line segments or arcs that join at nodes to product a polygon (CFIC 1988).

Polygon number: A unique number assigned to each polygon as it is delineated.

Prism: An optical instrument used as an angle gauge, consisting of a thin wedge of glass that establishes a fixed (critical) angle of projection in a point sample (Helms 1998).

Protection status: Protection status categories are based on International Union for Conservation (IUCN) categories I – VI: **0**) not protected (non-IUCN category), **1**) strict nature reserve: protected for science (IUCN category 1a), **2**) wilderness area: protected for wilderness (IUCN category 1b), **3**) national park: for ecosystem protection and recreation, **4**) natural monument: for conservation of specific natural features, **5**) habitat species management areas: for maintaining habitats, **6**) protected landscape seascape: for conservation and recreation, **7**) managed resource protected area: for sustainable use of natural ecosystems (IUCN 1994).

Regeneration: The continuous renewal of a forest stand (e.g., establishment of new young trees) by natural or artificial means (CCFM 1997).

Residual: A living remnant of a former stand; in even-aged stands, it is the occasional (< 25 per ha) large stem of an older age class than the stand as a whole. Typically, these trees may have larger diameters, a higher incidence or indications of decay, thicker bark, larger branching, and "ragged" or flat tops. These trees must be clearly residual. Uneven-aged stands do not generally have residual trees. **Residual trees are called Veterans in some inventories**.

Second leading species: The tree species with the second largest basal area per hectare based on all living trees ≥ 9.0 cm dbh in the Large Tree Plot. Residual trees from a previous stand are not included in the tally.

Seral stage: Any stage of development of an ecosystem from a disturbed, non-vegetated state to a climax plant community (Dunster and Dunster 1996).

Shrub: A woody perennial plant, typically shorter than most trees, having multiple stems that branch from the base without a well-defined main stem. It is often used as a descriptive term in a broad sense (Dunster and Dunster 1996).

Site index: A measure of forest site productivity expressed as the average height of the tallest trees in the stand at a defined index age (Dunster and Dunster 1996).

Site productivity: The inherent capabilities of a site to produce or provide the commodities or values for which the area will be managed (e.g., timber, forage, recreation, fisheries, wildlife, and water) (Dunster and Dunster 1996).

Site tree: Site trees are selected using defined criteria. The selected site trees have a height (called the Site Height) and an age (called the Site Age), which are used to calculate the site index for the stand (Iles 2003).

Small tree: For this inventory, a "tree" that is ≥ 1.3 m in height and < 9.0 cm dbh. It usually has a single trunk and a definite crown, which is capable of reaching a mature height of ≥ 5 m somewhere within its natural range. Small trees include all live standing, live fallen, and dead standing trees.

Small woody debris (SWD): For this inventory, dead woody material located above the litter layer, in various stages of decomposition. Small woody debris must be ≥ 1.0 cm and ≤ 7.5 cm in diameter (or equivalent cross-section) at transect crossing point, and not self-supporting. Trees and stumps intact in the ground are considered self-supporting.

Soil color: General color of the rooting-zone material.

Soil erosion cause and extent: Significant soil erosion (affecting > 30% of the plot); extent of soil erosion (> 30%).

Soil horizon: A layer of visually discernable organic or mineral of soil or soil material approximately parallel to the land surface (Dunster and Dunster 1996).

Soil moisture regime (SMR): The average amount of soil water annually available for evapotranspiration by vascular plants, averaged over several years (Klinka et al. 1984).

Soil nutrient regime (SNR): The amount of essential plant nutrients, particularly nitrogen, available to vascular plants over a period of several years (Klinka et al. 1984).

Soil pit: An excavation into the mineral soil of sufficient depth to allow assessment of variability in soil physical properties within a defined area of land (Dunster and Dunster 1996).

Stand: A community of trees sufficiently uniform in species composition, age, arrangement, and condition to be distinguishable as a group from the forest or other growth on the adjoining area, and thus forming a silviculture or management entity (Dunster and Dunster 1996).

Standing tree: Trees that are self-supporting (i.e., the tree would remain standing if all supporting materials were removed).

Stolon: A horizontal stem that grows along the surface of the soil and roots at the nodes (SRM 1989). A stoloniferous plant is a plant that has stolons.

Stump: See Tree stump.

Succession: Changes in the species composition of an ecosystem over time, often in a predictable order (CCFM 1997). The gradual supplanting of one community of plants by another, the sequence of communities being termed a sere and each stage seral (Helms 1998).

Succession stage: Any stage of development of an ecosystem from a disturbed, unvegetated state to a climax plant community (Dunster and Dunster 1996).

Surface water in forests: Lakes, rivers, streams, swamps.

Surficial material: Soil parent material.

Tall shrub: For this inventory, woody perennial plants ≥ 2.0 m in height above the ground surface, typically shorter than most trees, having multiple stems that branch from the base without a well-defined main stem. If any portion of the shrub extends ≥ 2.0 m then the entire shrub is measured as a tall shrub.

Tree: For this inventory, a woody plant, usually with a single stem and definite crown that is capable of reaching a mature height of 5.0 m somewhere within its natural range.

Tree biomass: Total aboveground biomass (kg/ha of oven-dry material) of trees ≥ 1.3 m tall.

Tree cover origin: Origin of the prevailing tree cover in the plot.

Tree species: For this inventory, a species listed in Appendix E: Canada's National Forest Inventory – Tree Species List. The species on this list are based on the "tree" definition. Tree species are listed by scientific name, common name, and a code for genus, species, and variety.

Tree stump: The woody base of a tree that remains after the rest of the tree has fallen as a result of decay or rotting or having been cut down (Dunster and Dunster 1996). For NFI purposes, stumps must be self-supporting, vegetatively dead, and ≥ 1.3 m in height.

Tree volume (gross total): Volume inside bark of the main stem, including stump and top as well as defective and decayed wood, of trees or stands (CFIC 1988).

Utilization: The proportion of current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole (SRM 1989). Utilization refers to the percentage of plant weight removed, not the percentage of plant height removed.

Vegetation layers: Within the Ecological Plots, all vegetation species will be listed and grouped by layer. Coverage will be estimated by species occurring in each layer. For this inventory, plant layers will be defined as follows:

A Layer (Trees):	Any species taller than 10 m in height. These are usually tree species. For the Ecological Plots, no subdivision of height within this layer is necessary.
B1 Layer (Tall Shrubs):	Includes woody species (tree and shrub) $\geq$ 2.0 m and $\leq$ 10 m in height. If *any* portion of the plant is > 2.0 m, then the whole plant is considered a tall shrub and will be treated as such.
B2 Layer (Low Shrubs):	Includes woody species (tree and shrub) < 2.0 m in height. Tree species $\geq$ 2 years old. These species will be included in the accepted NFI species lists. If *any* portion of the plant is $\leq$ 2.0 m, then the whole plant is considered a low shrub.
C Layer (Herbs):	Herbaceous species including forbs, ferns, grasses, sedges, rushes, saprophytes, club-mosses, horsetails, and some low woody species. These species will be included in the accepted NFI species lists.
D Layer:	Includes bryoids (mosses, liverworts, and foliose and fruticose lichens) and tree seedlings < 2 years old.

Vegetation press: Snowpress or damage that occurs due to aggressive vegetation that overtops the understory plant.

Vegetation type: Fifth level of Land Cover Classification Scheme. The distinct type of vegetation or non-vegetated condition of the land base within the plot.

Wildlife: Raptors, threatened species, endangered species, game, and other species of vertebrates prescribed as wildlife by regulation.

Wildlife tree: Dead, decaying, deteriorating, or other designated trees that provide present or future habitat for the maintenance or enhancement of wildlife (Dunster and Dunster 1996).

Woody debris (WD): Dead, non-self-supporting, woody material in various stages of decomposition that is located above the soil. It includes sound and rotting boles, limbs, large root masses, and uprooted stumps. Woody debris can also be in the form of felled and bucked logs or log decks. For this inventory, four sizes of woody debris have been defined:

Large coarse woody debris (LCWD):	Pieces > 30.0 cm in diameter.

Medium coarse woody debris (MCWD): Pieces > 7.5 cm and ≤ 30.0 cm in diameter.

Small woody debris (SWD): Pieces > 1.0 cm and ≤ 7.5 cm in diameter.

Fine woody debris (FWD): Pieces ≤ 1.0 cm in diameter.

References

Brack, C. 1999. Stand height for forest measurement and modeling. Australian National Univ., Dep. For. <http://sres-associated.anu.edu.au/mensuration/s_height.htm>.

BC Ministry of Forests. 2003. Glossary of forestry terms. Victoria, BC. <http://www.for.gov.bc.ca/hfd/library/documents/glossary>.

BC Ministry of Forests. 2007. Vegetation Resources Inventory ground sampling procedures. Version 4.7. Resource Inventory Branch, Victoria, BC. <http://www.for.gov.bc.ca/hts/vri/standards/index.html#vri>.

BC Ministry of Sustainable Resource Management, Terrestrial Information Branch. 2003. National Forest Inventory – British Columbia. Change monitoring procedures for provincial and national reporting. Version 1.3. Resources Inventory Committee, Victoria, BC.

(CCFM) Canadian Council of Forest Ministers. 1997. Criteria and indicators of sustainable forest management in Canada. Natural Resources Canada, Canadian Forest Service, Ottawa, ON. Cat. F075-3/6-1997E. Technical report.

(CFIC) Canadian Forest Inventory Committee. 1988. Forest inventory terms in Canada. 3rd ed. Forestry Canada, Petawawa National Forestry Institute, Chalk River, ON.

Dunster, J.; Dunster, K. 1996. Dictionary of natural resource management. Univ. BC Press, Vancouver, BC. 363 p.

(FAO) Food and Agriculture Organization of the United Nations. 2001. Global forest resources Assessment 2000 Main Report. FAO Rome, Italy. FAO Forestry Paper No. 140.

Helms, J. 1998. The dictionary of forestry. Society of American Foresters, Bethesda, MD. 210 p.

(IUCN) International Union for Conservation of Nature - The World Conservation Union. 1994. Guidelines for protected area management categories. CNPPA with the assistance of WCMC. Gland, Switzerland and Cambridge, UK x + 261 p.

Klinka, K.; Green, R.N.; Courtin, P.J.; Nuszdorfer, F.C. 1984. Site diagnosis, tree species selection, and slashburning guidelines for the Vancouver Forest Region. BC Min. For., Victoria, BC. Land Manage. Rep. No. 25.

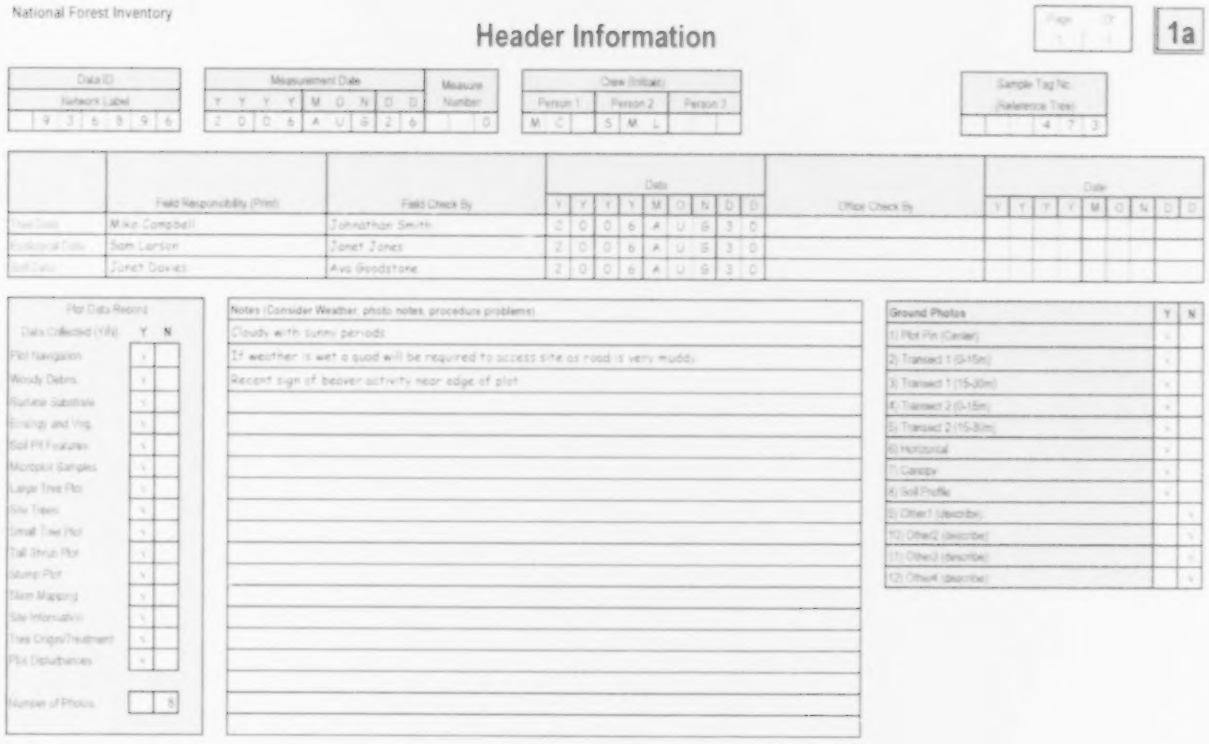
Lowe, J.J.; Power, K.; Gray, S.L. 1994. Canada's forest inventory 1991. Can. For. Serv., Petawawa Natl. For. Inst., Petawawa, ON. Info. Rep. PI-X-115.

(SRM) Society for Range Management. 1989. A glossary of terms used in range management. Society of Range Management, Denver, CO. ISBN 0-9603 692-8-7.

Soil Classification Working Group. 1998. The Canadian system of soil classification. 3rd ed. Agriculture and Agri-Food Canada Publication 1646. 187 p.

(UNECE/FAO) United Nations Economic Commission for Europe Food and Food and Agriculture Organization. 2000. Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand (industrialized temperate/boreal countries). UN-ECE/FAO Contribution to the Global Forest Resources Assessment 2000. Geneva Timber and Forest Study Papers, No. 17. Main Report. New York and Geneva.

Appendix B: Examples of Completed Field Cards



National Forest Inventory

Header Information

1a

Data ID	Measurement Date		Measure Number	Crew (Initials)			Sample Tag No. (Reference Tree)
Network Label	Y Y Y Y M O N D D			Person 1	Person 2	Person 3	
9 3 6 8 9 6	2 0 0 6 A U G 2 6		0	M C	S M L		4 7 3

	Field Responsibility (Print)	Field Check By	Date	Office Check By	Date
Tree Data	Mike Campbell	Johnathon Smith	20 06 AUG 30		
Ecological Data	Sam Larson	Janet Jones	20 06 AUG 30		
Soil Data	Janet Davies	Ava Goodstone	20 06 AUG 30		

Plot Data Points		
Data Collected (Y/N)	Y	N
Plot Navigation	Y	
Woody Debris	Y	
Surface Substrate	Y	
Ecology and Veg.	Y	
Soil Pit Features	Y	
Microplot Samples	Y	
Large Tree Plot	Y	
Site Trees	Y	
Small Tree Plot	Y	
Tall Shrub Plot	Y	
Stump Plot	Y	
Stem Mapping	Y	
Site Information	Y	
Tree Origin/Treatment	Y	
Plot Disturbances	Y	
Number of Photos		5

Notes (Consider Weather, photo notes, procedure problems)
Cloudy with sunny periods
If weather is wet a quad will be required to access site as road is very muddy
Recent sign of beaver activity near edge of plot

Ground Photos	Y	N
1) Plot Pin (Center)	Y	
2) Transect 1 (0-15m)	Y	
3) Transect 1 (15-30m)	Y	
4) Transect 2 (0-15m)	Y	
5) Transect 2 (15-30m)	Y	
6) Horizontal	Y	
7) Canopy	Y	
8) Soil Profile	Y	
9) Other1 (describe)		Y
10) Other2 (describe)		Y
11) Other3 (describe)		Y
12) Other4 (describe)		Y

Diagram 1 Header information card (1a).

National Forest Inventory

Header Information

Page 1 of 1

1b

Data ID
Network Label
9 3 6 8 9 6

Access Notes (For example "Start @ junction of Hwy 16 & 97 South 2.7 km on Hwy 16 Turn right 10.6 km on Log Main Road then turn left, etc.)	Map
Assess from route 11 approx. 12 km east of St Mary's interchange or 9 km form Janeville.	
Follow route as indicated on map copy left in file. Sections of this road are in very poor	
Leave route 11 on Johnson forest road to southeast	
left at 1.8 km on side road	
right onto side road at 3.4 km	
Cross creek at 3.8 km and park just past bridge	
Tie point is on west side of creek	
	Scale = 1: not to scale

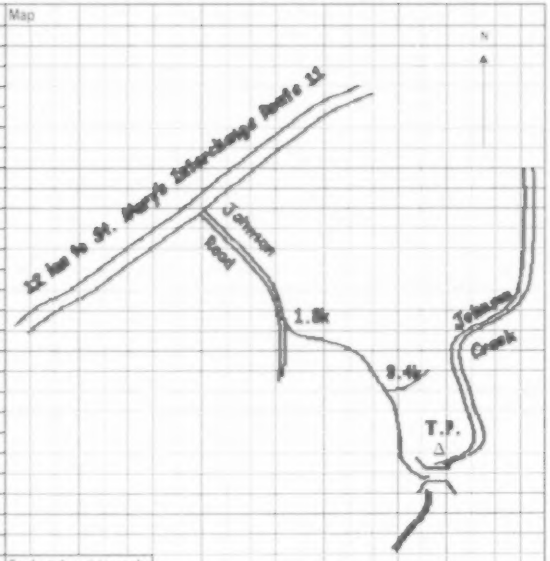


Diagram 2 **Header information card (1b) – Access notes.**

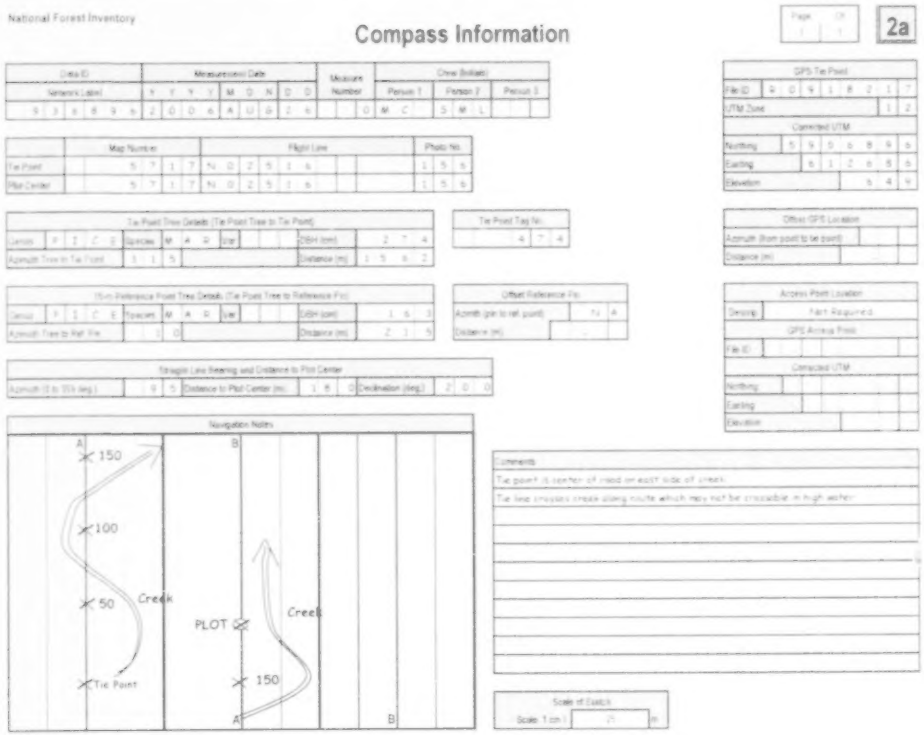


Diagram 3 **Compass information card (2a).**

National Forest Inventory

Cluster Diagram

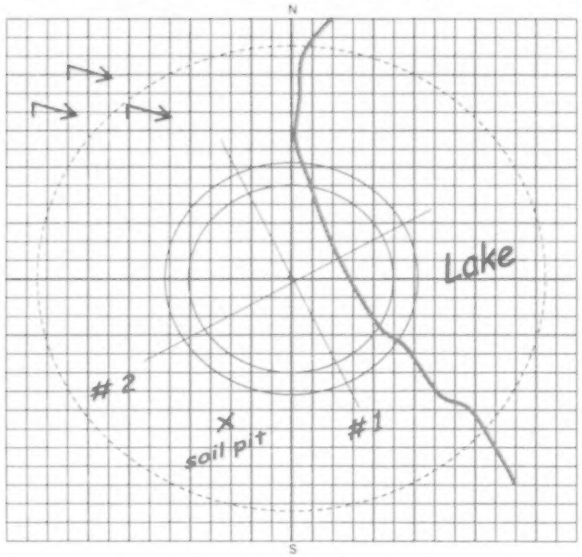
Page ___ Of ___ | 3

Date ID	Measurement Date							Measure Number	Crew (Initials)		
Network Label	Y	Y	Y	M	D	N	D	D	Person 1	Person 2	Person 3
1 2 9 2 9 2 1	2	0	0	6	A	U	G	0	8	0	J M	L D B	R T C

Map local features around ground plot center.

Include line transects, soil pit, and non-forested boundaries. Off plot site tree locations.

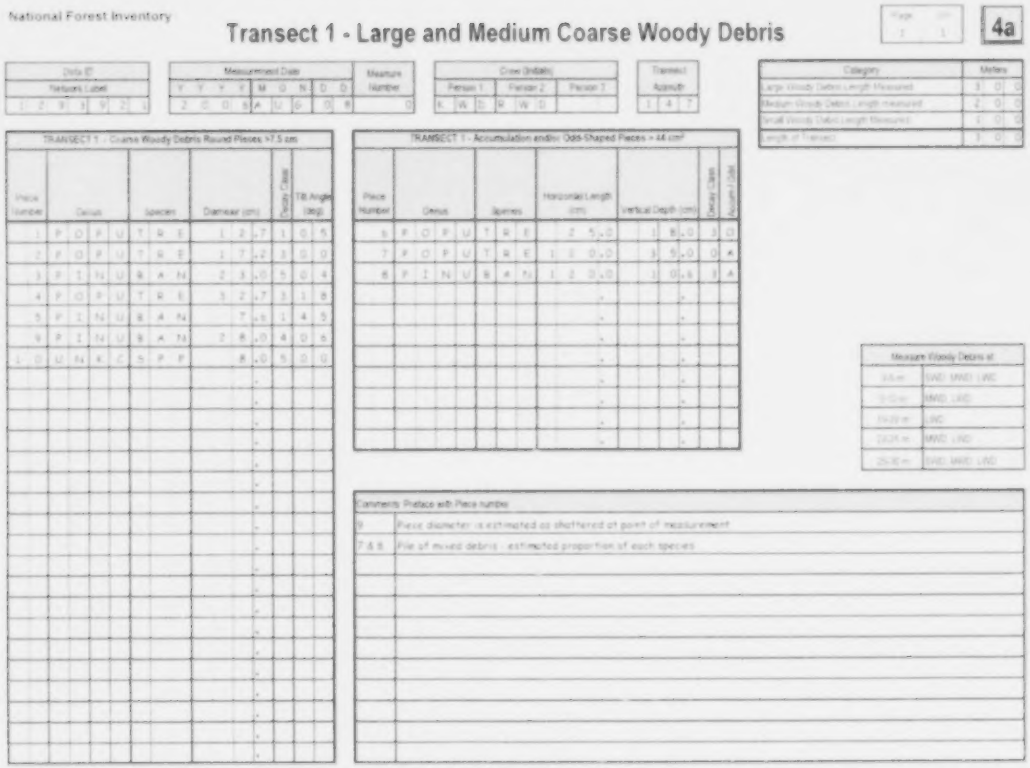
Draw features such as streams, rock outcrops, forest roads or skid trails, forest type changes or ecological boundaries, etc. that affect plot attributes.



Comments
PARTIAL SAMPLE - PORTION OF SAMPLE FALLS IN LAKE
TRANSECT 2 ENDS AT 6 METERS AT LAKE SHORE
LARGE TREE PLOT AND ECOLOGICAL PLOT ARE PARTIAL
EACH SQUARE EQUALS 4 SQUARE METERS
ECOLOGICAL PLOT - 13 SQUARES OUT OF PLOT x 4 m² = 52 m²
NOMINAL PLOT SIZE = 314 m² (0.0314 ha)
MEASURED PLOT SIZE = 314m² - 52m² = 262 m² (0.0262 ha)
LARGE TREE PLOT - 26 SQUARES OUT OF PLOT x 4 m² = 104 m²
NOMINAL PLOT SIZE = 400 m²
MEASURED PLOT SIZE = 400 m² - 104 m² = 296 m² = (0.0296 ha)

1 Sq = 4m² | Subplot Ing. n Site Description Area (Dec)

Diagram 4 **Cluster diagram card (3).**


National Forest Inventory

Transect 1 - Large and Medium Coarse Woody Debris

4a

Data ID	Measurement Date	Measure Number	Crew (Initials)			Transect Azimuth
Network Label	Y Y Y Y M O N D D		Person 1	Person 2	Person 3	
1 2 3 4 5 2 1	2 0 0 5 A U G 0 8	0	K W D	R W D		1 4 7

Category	Meters
Large Woody Debris Length Measured	3 0 0
Medium Woody Debris Length measured	2 0 0
Small Woody Debris Length Measured	1 0 0
Length of Transect	3 0 0

TRANSECT 1 - Coarse Woody Debris Round Pieces >7.5 cm

Piece Number	Genus	Species	Diameter (cm)	Decay Class	Tilt Angle (deg)
1	POPULUS	TREMULOIDES	12.7	1	05
2	POPULUS	TREMULOIDES	17.2	3	00
3	PINUS	BANKSIANA	23.0	5	04
4	POPULUS	TREMULOIDES	32.7	3	18
5	PINUS	BANKSIANA	7.6	1	45
6	PINUS	BANKSIANA	28.0	4	06
10	UNKNOWN	SPP	8.0	5	00

TRANSECT 1 - Accumulation and/or Odd-Shaped Pieces > 44 cm²

Piece Number	Genus	Species	Horizontal Length (cm)	Vertical Depth (cm)	Decay Class	Accum (Qty)
6	POPULUS	TREMULOIDES	250.0	18.0	3	01
7	POPULUS	TREMULOIDES	110.0	35.0	0	A
8	PINUS	BANKSIANA	120.0	10.6	3	A

Measure Woody Debris at
0.0 m	SAD, MAD, LAC
5.0 m	MAD, LAD
10.0 m	LAC
15.0 m	MAD, LAD
25.0 m	SAD, MAD, LAD

Comments: Preface with Piece number	
9	Piece diameter is estimated as shattered at point of measurement
7 & 8	Pile of mixed debris - estimated proportion of each species

Diagram 5 **Transect 1 – large and medium coarse woody debris card (4a).**

National Forest Inventory

Transect 1 - Small Woody Debris

Page	Of
1	1

4b

Data ID						
Network Label						
1	2	9	3	9	2	1

Measurement Date									Measure Number
Y	Y	Y	Y	M	O	N	D	D	
2	0	0	6	A	U	G	0	8	0

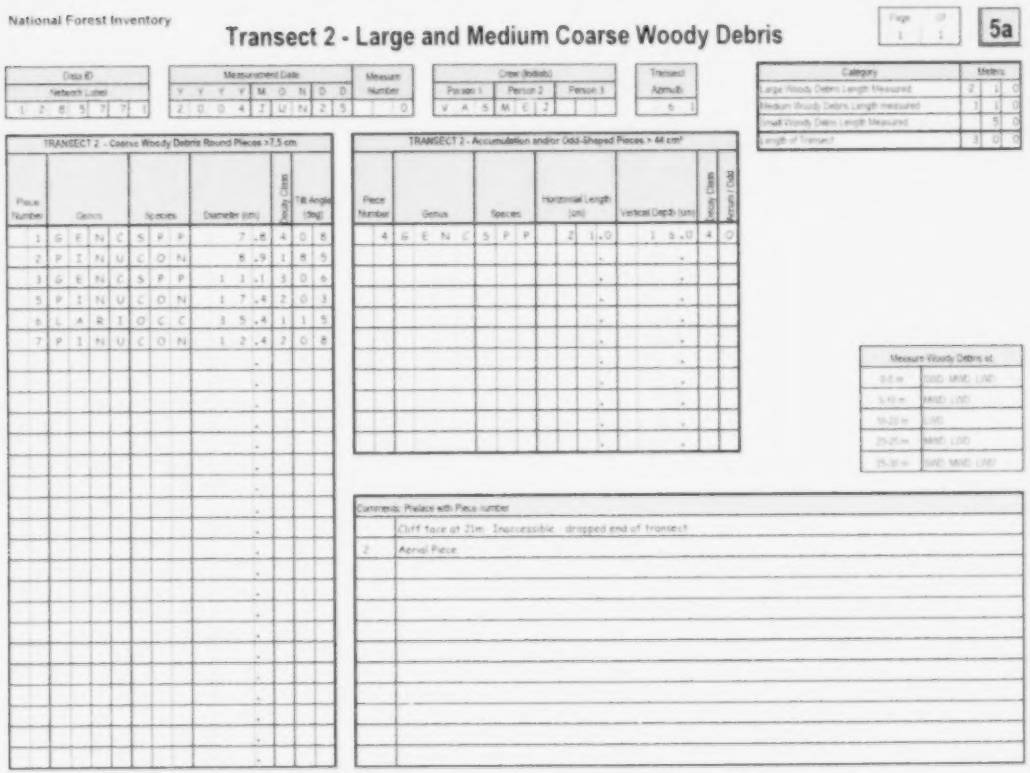
Crew (Initials)						
Person 1		Person 2		Person 3		
K	W	D	R	W	D	

SWD: Dot Tally Total Number of Pieces >0.8 and ≤ 44 cm²		
WORKSHEET ONLY - DATA WILL NOT BE KEYPUNCHED		
Class 1 (1.1 to 3.0 cm)	Class 2 (3.1 to 5.0 cm)	Class 3 (5.1 to 7.5 cm)
IIIII IIIII II	IIIII I	III

TRANSECT 1 (0 to 5 m and 25 to 30 m) - 1.0 < SWD ≤7.5cm		
Total Class 1 (1.1 to 3.0 cm)	Total Class 2 (3.1 to 5.0 cm)	Total Class 3 (5.1 to 7.5 cm)	Avg. Decay Class
12	6	3	3

Measure Woody Debris at:	
0-5 m	SWD, MWD, LWD
5-10 m	MWD, LWD
10-20 m	LWD
20-25 m	MWD, LWD
25-30 m	SWD, MWD, LWD

Diagram 6 **Transect 1 – small woody debris card (4b).**



National Forest Inventory

Transect 2 - Large and Medium Coarse Woody Debris

Page 1 of 1 — **5a**

Data ID	Measurement Date	Measure Number	Crew (Initials)	Transect Azimuth
Network Label	Y Y Y Y M O N D O D		Person 1 / Person 2 / Person 3	
1 2 8 5 7 7 1	2 0 0 4 J U N 2 5	0	V A S / M E /	6

Category	Meters
Large Woody Debris Length Measured	2 1 0
Medium Woody Debris Length measured	1 1 0
Small Woody Debris Length Measured	5 0
Length of Transect	3 0 0

TRANSECT 2 - Coarse Woody Debris Round Pieces >7.5 cm

Piece Number	Genus	Species	Diameter (cm)	Decay Class	Tilt Angle (deg)
1	GENUS	SPP	7.8	4	08
2	PINUS	CON	8.9	1	85
3	GENUS	SPP	11.1	3	06
5	PINUS	CON	17.4	2	03
6	LARIX	OCC	35.4	1	15
7	PINUS	CON	12.4	2	08

TRANSECT 2 - Accumulation and/or Odd-Shaped Pieces > 44 cm²

Piece Number	Genus	Species	Horizontal Length (cm)	Vertical Depth (cm)	Decay Class	Accum / Odd
4	GENUS	SPP	210.	130.	4	0

Measure Woody Debris at:
0-5 m: SWD MWD LWD
5-10 m: MWD LWD
10-20 m: LWD
20-25 m: MWD LWD
25-30 m: SWD MWD LWD

Comments: Preface with Piece Number
Cliff face at 21m. Inaccessible - dropped end of transect
2 Aerial Piece

Diagram 7 **Transect 2 – large and medium coarse woody debris card (5a).**

National Forest Inventory

Transect 2 - Small Woody Debris

Page	Of
1	1

5b

Data ID						
Network Label						
1	2	8	5	7	7	1

Measurement Date									Measure Number
Y	Y	Y	Y	M	O	N	D	D	
2	0	0	4	J	U	N	2	5	0

Crew (Initials)								
Person 1			Person 2			Person 3		
V	A	S	M	E	J			

SWD: Dot Tally Total Number of Pieces >0.8 and ≤ 44 cm²		
WORKSHEET ONLY - DATA WILL NOT BE KEYPUNCHED		
Class 1 (1.1 to 3.0 cm)	Class 2 (3.1 to 5.0 cm)	Class 3 (5.1 to 7.5 cm)
IIII II	III	IIII III

TRANSECT 2 (0 to 5 m and 25 to 30 m) - 1.0 < SWD ≤7.5cm			
Total Class 1 (1.1 to 3.0 cm)	Total Class 2 (3.1 to 5.0 cm)	Total Class 3 (5.1 to 7.5 cm)	Avg. Decay Class
7	3	9	2

Measure Woody Debris at:	
0-5 m	SWD, MWD, LWD
5-10 m	MWD, LWD
10-20 m	LWD
20-25 m	MWD, LWD
25-30 m	SWD, MWD, LWD

Diagram 8 **Transect 2 – small woody debris card (5b).**

National Forest Inventory

Transect 1 - Surface Substrate Tally

Page 1 of 2

6a

Data ID (Network Lab)	Measurement Date (YYYYMONDD)	Measure Number	Crew (Initials) Person 1	Person 2	Person 3	Transect Azimuth	Length of Transect Measured (m)
116134	2008JUN28	1	REW	BRB		81	30.0

Station	Substrate type (check one): Decayed Wood	Bedrock	Rock or Cobbles	Mineral Soil	Water	Organic	Buried Wood	Depth (cm) (measured for organic and buried wood substrates only)	Depth measured to... (check one): Mineral Soil	Bedrock	Frozen Layer	Sound Wood	Other or Unknown Impenetrable Object	Maximum depth (dm)
1						√		34.0	√					
2						√		26.0	√					
3						√		23.0	√					
4				√				.						
5						√		19.0	√					
6							√	31.0	√					
7						√		23.0	√					
8						√		24.0	√					
9						√		18.0	√					
10						√		15.0	√					
11						√		9.0	√					
12						√		11.0	√					
13								.						
14						√		21.0	√					
15						√		18.0	√					

Comments: Preface with station number
Example of shallow organic site.

Diagram 9 **Surface substrate tally card for Transect 1 (6a).**

National Forest Inventory

Transect 2 - Surface Substrate Tally

Page 2 Of 2

6b

Data ID: Network Label
1 1 3 2 4 3 4

Measurement Date									Measure Number
Y	Y	Y	Y	M	O	N	D	D	
2	0	0	8	J	U	L	1	2	1

Crew (Initials)								
Person 1			Person 2			Person 3		
G	L	R	J	R	V			

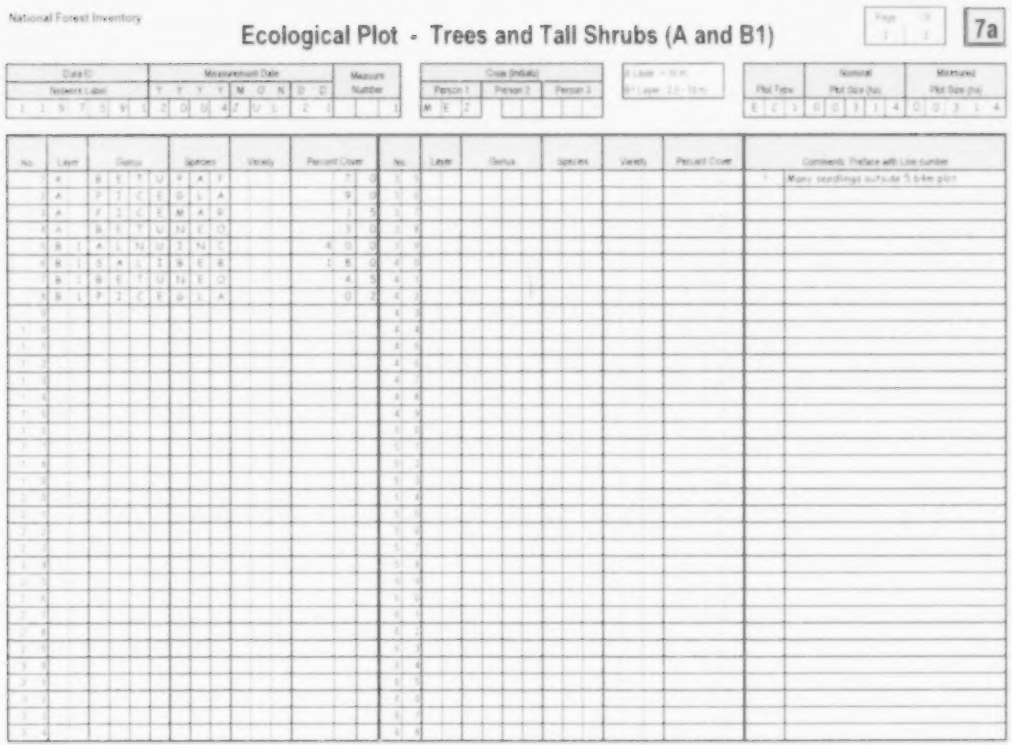
Transect Azimuth
1 6 7

Length of Transect Measured (m)								
3	0	.	0	↓	↑	3	0	.	0

Station	Substrate type (check one)							Depth (cm)			Depth measured to... (check one)					
	Decayed Wood	Bedrock	Rock or Cobbles	Mineral Soil	Water	Organic	Burned Wood	(measured for organic and buried wood substrates only)			Mineral Soil	Bedrock	Frozen Layer	Sound Wood	Other or Unknown Impenetrable Object	Maximum Depth (5m)
1						√		5	0	0.0						√
2						√		3	5	0.0	√					
3						√		4	7	5.0	√					
4						√		1	3	0.0					√	
5						√		3	9	0.0	√					
6						√		4	1	5.0	√					
7					√					.						
8										.						
9										.						
10										.						
11										.						
12										.						
13										.						
14										.						
15										.						

Comments: Preface with station number	
	Example of deep organic site

Diagram 10 **Surface substrate tally card for Transect 2 (6b).**



National Forest Inventory

Ecological Plot - Trees and Tall Shrubs (A and B1)

7a

Data ID							Measurement Date							Measure Number
Network Label							Y	Y	Y	Y	M	O	N	D	D	
I	I	9	7	5	W	1	2	0	0	4	J	U	L	2	1	1

Crew (Initials)		
Person 1	Person 2	Person 3
M E	J	

B Layer = 5-9 m
B1 Layer = 2.0 - 5.0 m

Plot Type	Nominal Plot Size (ha)				Measured Plot Size (ha)			
E	C	1	0	0	3	1	4	0	0	3	1	4

No.	Layer	Genus	Species	Variety	Percent Cover	No.	Layer	Genus	Species	Variety	Percent Cover	Comments: Preface with Line number
	A	B E T U	P A P		T 1	1						1 Many seedlings outside 5.64m plot
	A	P I C O	G L A		9 2	2						
	A	F I C O	M A G		1 5	3						
	A	B E T U	N E O		3 0	4						
	B 1	A L N U	I N C		4 0	5						
	B	S A L I	S E S		1 5	6						
	B	B E T U	N E O		4 5	7						
	B 1	P I C O	G L A		0 2	8						
						9						
						10						
						11						
						12						
						13						
						14						
						15						
						16						
						17						
						18						
						19						
						20						
						21						
						22						
						23						
						24						
						25						
						26						
						27						
						28						
						29						
						30						
						31						
						32						

Diagram 11 **Ecological Plot -- Trees and Tall Shrubs card (7a).**

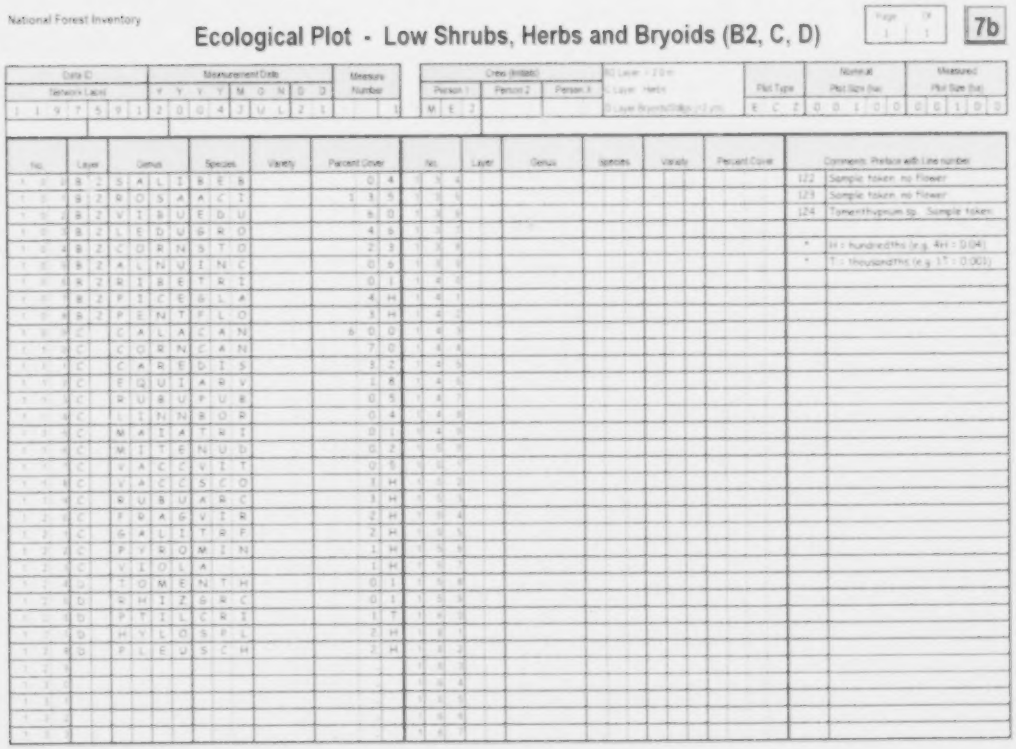
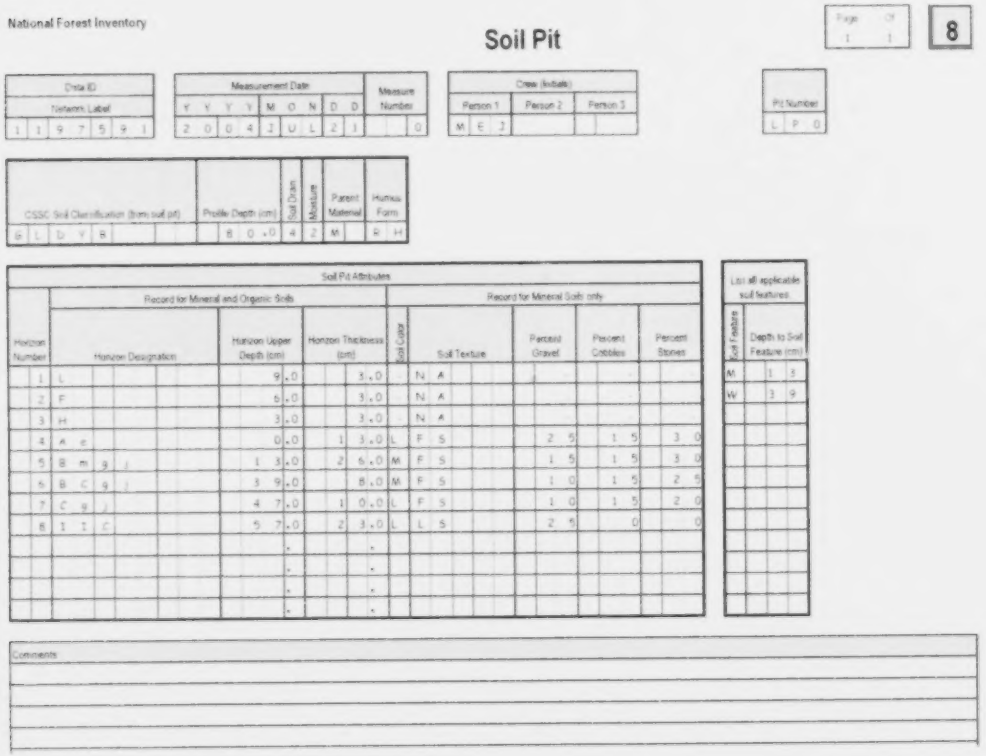


Diagram 12 **Ecological Plot – low shrubs, herbs, and bryoids card (7b).**



National Forest Inventory

Soil Pit

Page 1 Of 1

8

Data ID	Measurement Date								Measure Number	Crew (Initials)			Pit Number
Network Label	Y	Y	Y	Y	M	O	N	D	D	Person 1	Person 2	Person 3	
1 1 9 7 5 9 1	2	0	0	4	J	U	L	2	1	M E J			L P 0

CSSC Soil Classification (from soil pit)	Profile Depth (cm)	Soil Drain	Moisture	Parent Material	Humus Form
G L D Y B	8 0 .0	4	2	M	R H

Soil Pit Attributes

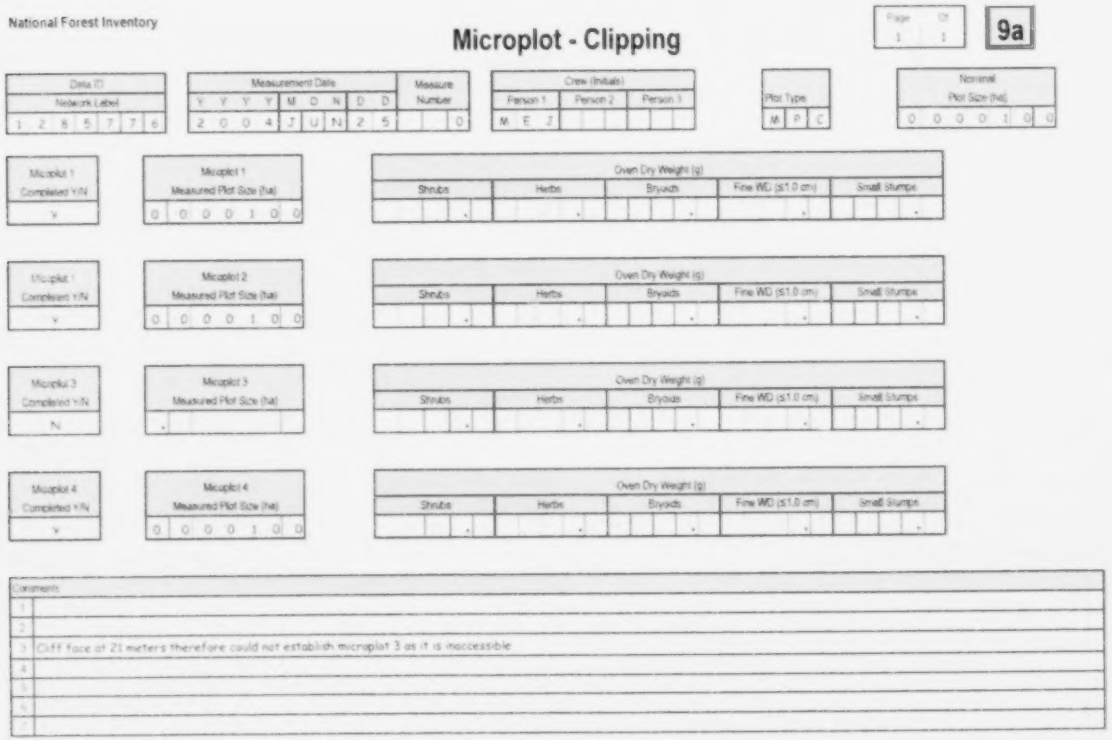
Horizon Number	Record for Mineral and Organic Soils: Horizon Designation	Horizon Upper Depth (cm)	Horizon Thickness (cm)	Record for Mineral Soils only: Soil Color	Soil Texture	Percent Gravel	Percent Cobbles	Percent Stones
1	L	9.0	3.0		N A			
2	F	6.0	3.0		N A			
3	H	3.0	3.0		N A			
4	A e	0.0	13.0	L	F S	2 5	1 5	3 0
5	B m g j	13.0	26.0	M	F S	1 5	1 5	3 0
6	B C g j	39.0	8.0	M	F S	1 0	1 5	2 5
7	C g j	47.0	10.0	L	F S	1 0	1 5	2 0
8	I I C	57.0	23.0	L	L S	2 5	0	0
		.	.					
		.	.					
		.	.					
		.	.					

List all applicable soil features

Soil Feature	Depth to Soil Feature (cm)
M	15
W	39

Comments

Diagram 13 **Soil pit card (8).**



National Forest Inventory

Microplot - Clipping

Page 1 Of 1 — **9a**

Data ID	Measurement Date			Measure Number	Crew (Initials)			Plot Type	Nominal Plot Size (ha)
Network Label	Y Y Y Y	M D	D D		Person 1	Person 2	Person 3		
1 2 8 5 7 7 6	2 0 0 4	J U	N 2 5	0	M E J			M P C	0 0 0 0 1 0 0

Microplot 1 Completed Y/N	Microplot 1 Measured Plot Size (ha)	Oven Dry Weight (g)				
		Shrubs	Herbs	Bryoids	Fine WD (≤1.0 cm)	Small Stumps
Y	0 0 0 0 1 0 0	.	.	.	.	.

Microplot 2 Completed Y/N	Microplot 2 Measured Plot Size (ha)	Oven Dry Weight (g)				
		Shrubs	Herbs	Bryoids	Fine WD (≤1.0 cm)	Small Stumps
Y	0 0 0 0 1 0 0	.	.	.	.	.

Microplot 3 Completed Y/N	Microplot 3 Measured Plot Size (ha)	Oven Dry Weight (g)				
		Shrubs	Herbs	Bryoids	Fine WD (≤1.0 cm)	Small Stumps
N	.	.	.	.	.	.

Microplot 4 Completed Y/N	Microplot 4 Measured Plot Size (ha)	Oven Dry Weight (g)				
		Shrubs	Herbs	Bryoids	Fine WD (≤1.0 cm)	Small Stumps
Y	0 0 0 0 1 0 0	.	.	.	.	.

Comments	
1	
2	
3	Cliff face at 21 meters therefore could not establish microplot 3 as it is inaccessible
4	
5	
6	
7	

Diagram 14 **Microplot – clipping card (9a).**

National Forest Inventory

Microplot - Forest Floor and Soil Samples

Page 1 Of 1 — 9b

Data ID	Measurement Date	Measure Number	Crew (Initials)		
Notes - Label	Y Y Y Y M O N D D		Person 1	Person 2	Person 3
1 2 8 5 7 7 6	2 0 0 4 J U N 2 5	0	M E J		

Forest Floor Samples

Microplot No.	Sample No.	Horz. Meas.	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Meth.	Template Width (cm)	Template Length (cm)	Volume of Sample (mL)
M P 1	1	D	L/F/H	0 0	1 2 4	H	2 0	2 0	4 9 6 0
M P 2	2	D	L/F/H	0 0	1 5 5	H	2 0	2 0	6 2 0 0
M P 4	3	D	L/F/	0 0	1 0 3	H	2 0	2 0	4 1 2 0
M P 4	4	D	L/F/H	1 0 3	1 9 6	H	2 0	2 0	7 3 2 0

Comments:
- MP1 was dropped. Cliff face at 21.3 m on transect.
- No samples were taken.
- MP4 had thick Forest Floor Organics.
- Samples are in two bags.

Organic Soil Samples

Microplot No.	Sample No.	Horz. Meas.	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Meth.	Template Width (cm)	Template Length (cm)	Volume of Sample (mL)

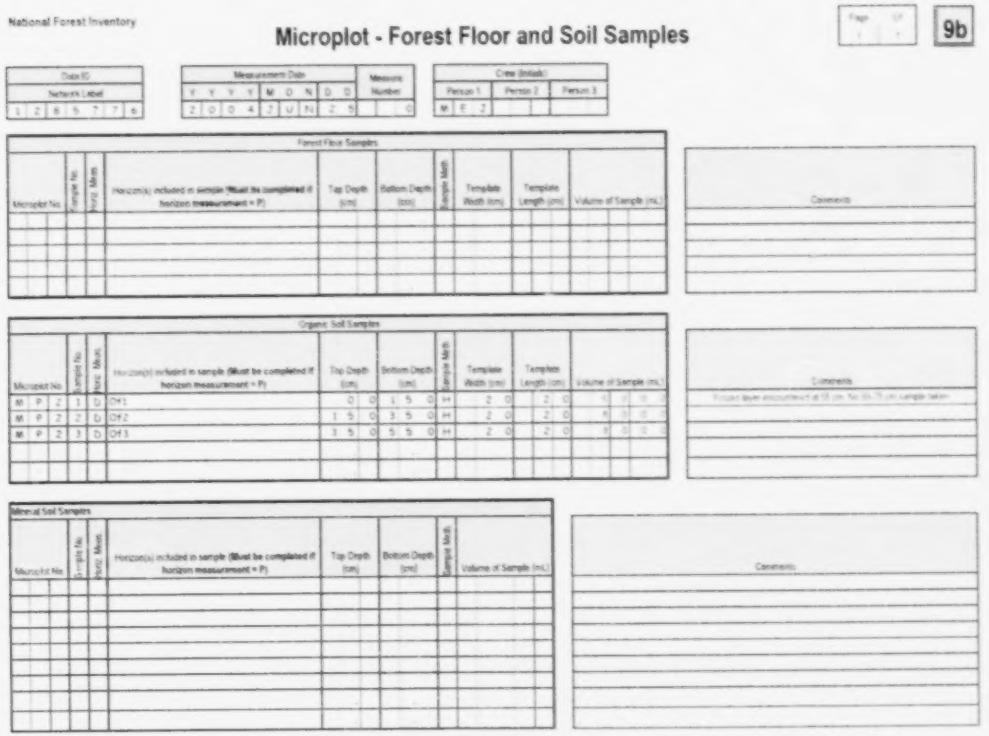
Comments:

Mineral Soil Samples

Microplot No.	Sample No.	Horz. Meas.	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Meth.	Volume of Sample (mL)
M P 1	1	D	Ash/Ae/Ae	0 0	1 5 0	H	9 2 0
M P 1	2	D	Bm/BC	1 5 0	3 5 0	H	9 2 0
M P 1	3	D	BC	3 5 0	5 5 0	H	1 4 9 0
M P 2	4	D	Ash/Ae/Ae	0 0	1 5 0	H	6 4 0
M P 2	5	D	Bm/BC	1 5 0	3 5 0	H	1 0 2 0
M P 1	6					F	1
M P 4	7	D	Ash/Ae/Ae	0 0	1 5 0	H	6 4 0

Comments:
- MP1 was dropped. Cliff face at 21.3 m on transect.

Diagram 15 **Microplot – forest floor and soil samples card: mineral soils example (9b).**


National Forest Inventory

Microplot - Forest Floor and Soil Samples

Page 1 of 1

9b

Data ID / Network Label: 1 2 8 5 7 7 6

Measurement Date: Y Y Y Y M O N D D = 2 0 0 4 J U N 2 5

Measure Number: 0

Crew (Initials): Person 1 M E J; Person 2; Person 3

Forest Floor Samples

Microplot No.	Sample No.	Horiz. Mtrls	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Mtrls	Template Width (cm)	Template Length (cm)	Volume of Sample (mL)

Comments

Organic Soil Samples

Microplot No.	Sample No.	Horiz. Mtrls	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Mtrls	Template Width (cm)	Template Length (cm)	Volume of Sample (mL)
M P 2	1	O	Of1	0 0	1 5 0	H	2 0	2 0	6 0 0
M P 2	2	O	Of2	1 5 0	3 5 0	H	2 0	2 0	4 0 0
M P 2	3	O	Of3	3 5 0	5 5 0	H	2 0	2 0	4 0 0

Comments

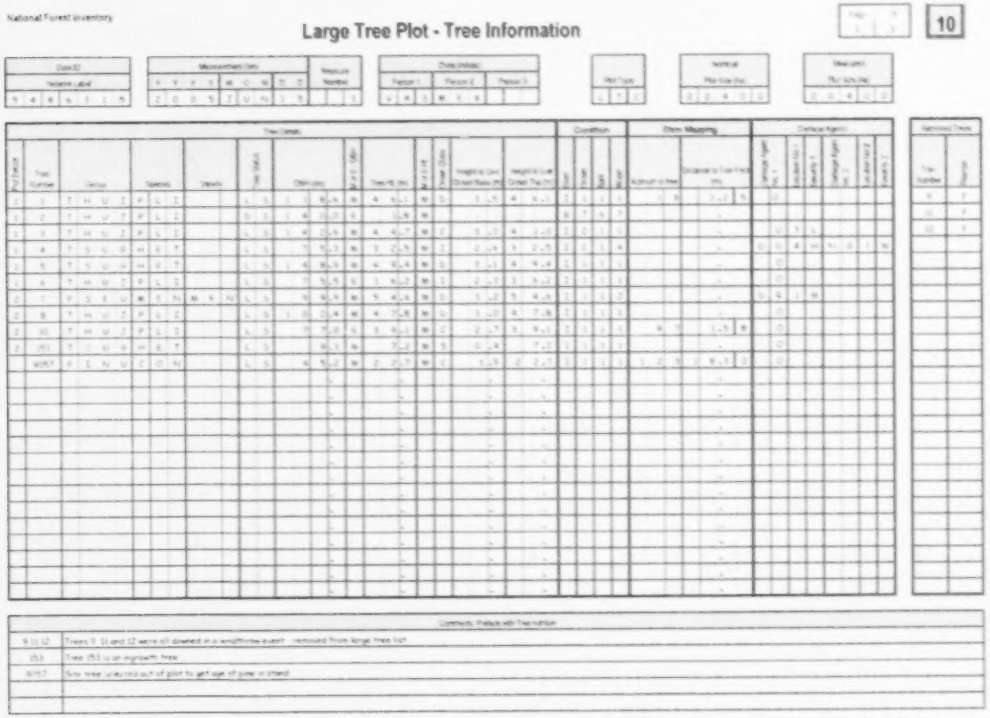
Frozen layer encountered at 35 cm. No 55-75 cm sample taken.

Mineral Soil Samples

Microplot No.	Sample No.	Horiz. Mtrls	Horizon(s) included in sample (Must be completed if horizon measurement = P)	Top Depth (cm)	Bottom Depth (cm)	Sample Mtrls	Volume of Sample (mL)

Comments

Diagram 16 **Microplot – forest floor and soil samples card: organic soils example (9b).**


National Forest Inventory

Large Tree Plot - Tree Information

10

Diagram 17 **Large Tree Plot – tree information card (10).**

National Forest Inventory

Large Tree Plot - Site Tree and Age Information

Page 1 of 1 | 11

Data ID	Measurement Date	Measure Number	Crew (Initials)		
Ymkunt Label	Y Y Y Y M O N D D		Person 1	Person 2	Person 3
0 4 8 6 J 1 5	2 0 0 5 J U N 1 5	1	V A S	M E F	

Site Tree and Age Information

Quadrant	Tree Number	Site Type	Boring DOB (cm)	Boring Ht (m)	Pith Hit Y/N	Field Count Age	Est Age (Yr)	Provenb Code
N W	5	T	1 4 8 .9	1 .3	Y	8	Y	
N W	5	L	1 4 8 .9	1 .3	Y	8	Y	
S E	8	L	1 0 2 .4	1 .3	Y	8	Y	
S W	2 1	L	8 5 .6	1 .3	N	2 4 6	Y	
N W	2 9	L	9 7 .6	1 .0	Y	9 0	Y	R O T
S E	1 8	S	7 8 .9	1 .3	Y	1 8 9	Y	
N W	1 5	S	8 1 .5	1 .3	Y	1 9 7	Y	
S E	7 2		9 9 .9	1 .3	Y	8	N	
O P	9 0 2 7 5		6 5 .2	1 .3	Y	1 5 6	Y	
O P	9 0 5 7 N		4 5 .2	1 .3	Y	8 9	Y	

Comments: Preface with tree number	
5 7 8	Trees cored in previous measurement
29	Rotten centre - field count is based on the 18.1 cm of sound core
9027	Out of tree plot was chosen to represent tree 27 as could not
	physically reach #27 to bore
9057	Site tree selected out of plot to get age of pine in stand

NOTE: All site trees must be included in the large tree information list

Diagram 18 **Large Tree Plot – site tree and age information card (11).**

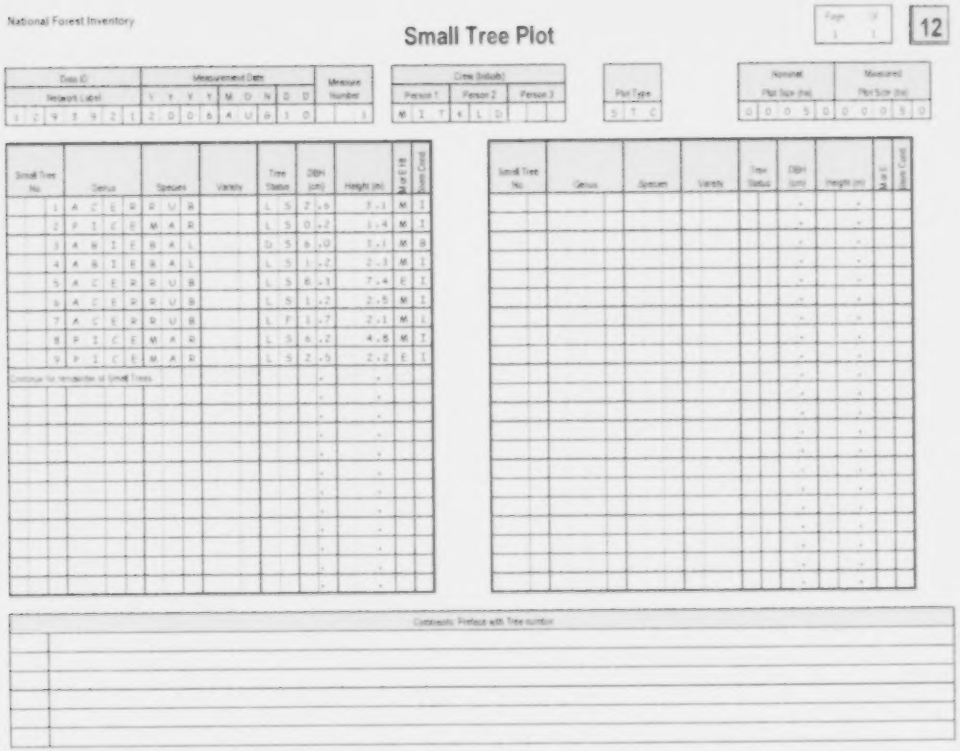


Diagram 19 **Small Tree Plot card (12).**

National Forest Inventory

Shrub Plot

Page 1 of 1 | **13**

Data ID							Measurement Date								Measure Number	
Network Label							Y	Y	Y	Y	M	O	N	D	D	
S	1	2	6	5	4	8	2	0	0	6	J	U	L	2	4	0

Crew (Initials)									
Person 1			Person 2			Person 3			
K	R	N	G	R	T				

Plot Type
S T C

Nominal Plot Size (ha)					Measured Plot Size (ha)				
0	0	0	5	0	0	0	0	5	0

Shrub No	Genus	Species	Variety	Status	BD Class	Int. Class	Frequency
1	OPPL	HOR		LV	0	1	1
2	OPPL	HOR		LV	2	1	2
3	RUBU	SPE		LV	1	2	1
4	RUDU	SPE		DS	1	1	1
5	OPPL	HOR		LV	3	2	2
6	OPPL	HOR		LV	4	2	1
Continue for remainder of shrubs							

Shrub No	Genus	Species	Variety	Status	BD Class	Int. Class	Frequency

Comments: Preface with Shrub number

Diagram 20 **Shrub Plot card (13).**

National Forest Inventory

Stump Plot

Page 1 Of 1 — **14**

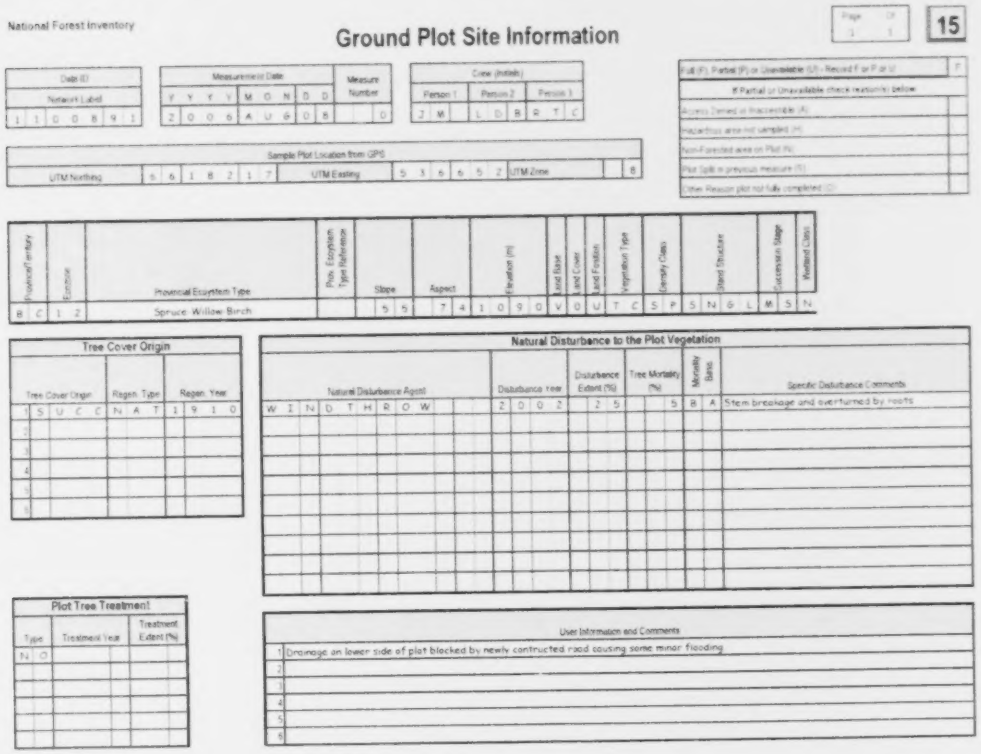
Data ID	Measurement Date		Measure Number	Crew Initials			Plot Type	Nominal Plot Size (ha)	Measured Plot Size (ha)
Network Label	Y Y Y Y	M O N	D D	Person 1	Person 2	Person 3			
5 7 4 6 8 9 1	2 0 0 7	J U N	1 6	M R C	L B		S T C	0 0 5 0	0 0 5 0

Stumps ≤ 1.3 m in length with a top DIB ≥ 4.0 cm

Stump No.	Genus	Species	Variety	Top diameter inside bark (cm)	Top diameter including bark, if present (cm)	Stump Length (m)	Piece Class
1	THUJ	PLI		27.6	27.6	0.5	5 2
2	TSUG	HET		65.0	69.0	1.1	5 4
3	TSUG	HET		1.2	1.2	0.0	5 3
4	THUJ	PLI		10 3.5	12 7.7	0.6	5 3
5	TSUG	HET		3.9	3.9	0.6	0 3
Continue for remainder of Stumps				.	.	.	

Comments: Preface with Stump number

Diagram 21 **Stump Plot card (14).**



National Forest Inventory

Ground Plot Site Information

Page 1 of 1

15

Date ID	Measurement Date	Measure Number	Crew (Initials)		
Network Label	Y Y Y Y M O N D D		Person 1	Person 2	Person 3
1 1 0 8 9 1	2 0 0 6 A U G 0 8	0	J M	L D	B R T C

Full (F), Partial (P) or Unavailable (U) - Record F or P or U: F

If Partial or Unavailable check reason(s) below:

- Access Denied or Inaccessible (A)
- Hazardous area not sampled (H)
- Non-Forested area on Plot (N)
- Plot Split in previous measure (S)
- Other Reason plot not fully completed (O)

Sample Plot Location from GPS

UTM Northing							UTM Easting						UTM Zone		
	5	6	1	8	2	1	7	5	3	6	6	5	7		8

Provincial Territory	Ecozone	Provincial Ecosystem Type	Prov. Ecosystem Type Reference	Slope	Aspect	Elevation (m)	Land Base	Land Cover	Land Position	Vegetation Type	Density Class	Stand Structure	Succession Stage	Wetland Class
B C	1 2	Spruce Willow Birch		5 5	7 4	1 0 9 0	V	0	U	T C	S P	S N G L	M S	N

Tree Cover Origin

	Tree Cover Origin	Regen. Type	Regen. Year
1	S U C C	N A T	1 9 1 0
2			
3			
4			
5			
6			

Natural Disturbance to the Plot Vegetation

	Natural Disturbance Agent	Disturbance Year	Disturbance Extent (%)	Tree Mortality (%)	Mortality Status	Specific Disturbance Comments
1	W I N D T H R O W	2 0 0 2	2 5	5	B A	Stem breakage and overturned by roots
2						
3						
4						
5						
6						
7						
8						
9						
10						

Plot Tree Treatment

	Type	Treatment Year	Treatment Extent (%)
1	N O		
2			
3			
4			
5			
6			

User Information and Comments

1	Drainage on lower side of plot blocked by newly contructed road causing some minor flooding
2	
3	
4	
5	
6	

Diagram 22 Ground Plot site information card (15)

Appendix C: Hidden Plot Procedures

The following hidden plot procedures were adapted from *National Forest Inventory – British Columbia, Change Monitoring Procedures for Provincial and National Reporting* (BC Ministry of Sustainable Resource Management, March 31, 2003, Version 1.3).

Introduction

Ground sampling procedures will need to be modified where a ground plot, or the access route to a ground plot, falls within special management areas such as parks and recreation sites, private lands, or areas that are in high use by the public. *If a province/territory already has its own procedures designated for dealing with hidden plots, they should be employed instead and these procedures referenced as a backup.* Custodians of the lands in question (e.g., the private landowner) should always be contacted to determine their specific requirements and to obtain permission to locate the sample. Consultation with the custodian will also help determine which of the modifications below need to be used. All samples on private land or special areas of interest must:

1. have a signed agreement with the landowner on file; and
2. have a description of the agreed-upon plot marking procedures signed and on file.

The following document is to be used by project managers, when planning sampling projects, as a guide on how to modify the sample marking procedures on such samples and how to go about relocating them for audits or other uses. In general, the modifications should not significantly affect the time it takes to establish a sample.

Modifications to Marking Procedures

These modifications are designed to make the sample as "invisible" to a casual observer at the sample as possible. Some items such as soil pits will be somewhat visible regardless of procedure modifications.

1. Do not ribbon, spray paint, blaze, or limb any tree on the sample, including the tie-point or reference tree. Crews may wish to temporarily hang a ribbon on trees in the sample cluster to aid in measurement and reduce confusion, but must remove them before leaving the sample.
2. The route from Tie-point Tree to Reference Point location should not be ribboned, and there must not be any ribbon from the plot center. Crews may place ribbon for use while at the plot (e.g., to aid in estimating cover for Ecological Plots), but all ribbon must be removed before leaving the site.
3. The full length of all plot stakes is to be inserted into the ground, including the reference tree pin, the plot center pin, and the auxiliary plot pins. The crews may wish to cut the pins in half to ensure that their entire length can be inserted into the ground or crews may want to carry a pipe cutter or hacksaw to custom cut the stakes to length on site. To assist relocation with a metal detector, place a large iron nail inside the aluminum pipe (ensure the nail head is large enough to prevent the nail from sliding to the bottom of the stake). If

appropriate, a small cairn of rocks can be placed around the location of the stake.

4. CWD intersections are not to be painted or otherwise marked, but a stick or branch should be pushed into the ground at the end of each transect.

5. Additional effort to collect GPS positions in the field should be expended for the plot center and the tie-point.

6. All large trees in the plot should be stem mapped to aid in relocating the plot center pin.

7. Any additional photos that would aid in relocating the plot center should be taken.

8. The reference tree tag and the tie-point tag should still be placed where allowed. These are not highly visible unless someone is specifically looking for it. The tags should be placed at or near ground level, possibly covered by loose rocks or woody debris.

9. Record in the comments section of the plot location tally card that the sample is a "hidden" sample, and briefly list the modifications to procedures. This will aid future crews to the sample in planning how to relocate the plot center.

10. It is expected that increment boring should be allowed on nearly all sites.

Suggested Methods for Relocating the Plot Center for Audit or Other Uses

Planning before leaving for the field will significantly reduce the time it takes to relocate a hidden sample. The procedures listed below have been tested and the extra time to relocate a hidden sample can be minimal given proper planning.

On some samples, the tie-point will be very distinct and the tie line from the tie-point to the plot center will be short. On samples such as these, conventional chaining methods could be used to relocate the general area for the plot center pin. A real-time corrected GPS unit is an asset to confirm the location.

Samples where the tie-point is indistinct and/or the tie line is long may require the use of real-time corrected GPS. The crew revisiting the sample should obtain the corrected coordinates for the sample before leaving for the field. Using the real-time GPS unit, the crew can navigate to the approximate location of the plot center pint, or offset as applicable. Real-time GPS is necessary on long tie lines as even a small change in bearing when re-chaining the line can result in the revisit crew being far enough away from the original plot center location that relocating it could be impossible.

Once in the general area of the plot center, the re-visit crew should look for the reference tree tag, soil pit, and plot center pins (where allowed) that are the most visible signs of being near the plot center. If the reference tag is found, the crew should be able to find the reference pin using the reference tree details on the original plot location card. The soil pit will indicate that the plot center is near, and may have been drawn on the plot details tally card. Other clues to look for are the species in the area (such as a lone spruce in the plot where the rest of the trees are pine), or an overly large tree in the plot. The crew can take the diameter of one of these trees to see if it matches on the original cards. If it does, the stem map can be used to further refine the plot center pin location. Increment borer holes on trees are another sign that the plot center vicinity has been

reached; they should be visible if the time between establishment and re-visit in not great enough to have allowed the scars to heal.

A plot center stake that has been buried may require the use of a metal detector to determine the exact location of the plot center. The metal detector can be used systematically to cover the general area where the plot center pin is located. Crews should ensure that they use a metal detector that can identify aluminum, as some can only identify ferro-magnetic materials (iron). The user manual for a detector will tell what materials it can detect.

Appendix D: Handling Unavailable, Difficult Access, and Partial Ground Plot Sites

Unavailable and Difficult Access Ground Plot Sites

Background

This document provides guidelines for handling unavailable and difficult access ground plot sites for the National Forest Inventory (NFI). For NFI purposes, a ground plot site is deemed:

- *Unavailable (or inaccessible):* if the plot center (hence, the entire ground plot) cannot be visited owing to permanent danger or denied access to the field crew. The field crew makes this determination. However, as much as possible, the project manager should determine ahead of time the status of the plot locations.

- *Difficult access:* if the plot establishment is estimated to take more time or resources than normally anticipated (e.g., > 2 days). The project manager determines this.

Ignoring both unavailable and difficult access sites results in missing data and hence, potential bias. Simply replacing the unavailable or difficult access site with another site from the potential sample list will not eliminate the potential bias. This is the classical statistical non-response problem. There is no exact solution to this problem without other penalties. The question then is, how do we replace the missing data to minimize potential bias? Guidelines for the NFI are described below.

Unavailable Sites

The following guidelines for handling an unavailable site are suggested for the project manager:[1]

1. Attempt to replace each unavailable site with a *matched* (available) site. The primary objective of matching is to select a substitute-sampling site that will provide a full set of ground plot measurements and remeasurements with minimum bias.

[1] These guidelines have been adapted, with some modifications, from the approach used in British Columbia (BC Resources Information Standards Committee: *National Forest Inventory – British Columbia, Data Collection Procedures for Inaccessible Grid Locations*, version 1.0, March 31, 2003).

For each inaccessible grid point, find potential "suitable" matches (1–3 sites) using mid-scale (e.g., scale 1:20 000) aerial photography. Search systematically the 4 × 4 km network nodes within a 20 × 20 km area surrounding the inaccessible grid point.

2. Use the following suggested matching criteria for the inaccessible grid point (in order):

    a. Same ecozone within the province or territory.

    b. Same NFI Land Cover Classification Scheme (up to level 5).

    c. Similar leading or second tree species, height, and age. Similarity comparisons of the tree characteristics should consider the measurement standards and tolerances set by the individual provinces/territories.

    d. Same aspect and elevation description.

    The province/territory may also use additional matching criteria, if desired.

3. If no suitable matching site is found, then drop the unavailable site and indicate so in the database. Other methods for replacing the missing data, such as replacement with strata means, model predictions, or imputations, will be considered for the dropped plots during data analysis.

4. Instruct the field crew to visit the potential matching sites in the order indicated by the project manager.

5. After the matched site has been identified, the new site should be visited on the ground to collect measurements following the same sampling procedures as for regular NFI grid locations.

6. Document the matched sites in the database and the link with the original unavailable site.

Please see the British Columbia paper[1] for further discussion of the unavailable site issues, options, and detailed matching procedures as used in British Columbia. Other provinces and territories could use this document as a start when preparing their own procedures.

Note that matching should not be considered in the case of partially or temporarily unavailable sites. That is:

- If only part of the plot is unavailable, measure and map the portion that can be visited (provided the center can be visited).

- If only some of the data for a plot are missing (unavailable) (e.g., when a crew is not permitted to bore trees to measure ages), collect as much of the available data as possible.

- If the cause of the danger is temporary (such as a wildlife encounter), the crew will return to establish the original sample after the threat is gone.

Difficult Access Sites

The following guidelines for handling difficult access sites are suggested for the project manager:

1. Conduct a preliminary access assessment for all of the plot sites.
2. *Visit all of the difficult access sites* if their number is small (< 3 locations).
3. *Reduce total sample size* either at the planning stage, considering the available resources and time, or randomly subsample the difficult access sites, if the number of anticipated difficult access sites is large (≥ 3 sites). The primary objective of reducing the sample size is to reduce the overall cost and time it takes to establish the difficult access plots, without introducing a bias.
    a. Subsampling by ecozone within province/territory involves the following:
        i. The project manager assesses all the sample grid points to determine the difficult access sites.
        ii. The project manager selects a small subsample at random from the group of the sites deemed to be difficult to access in an ecozone. The size of the subsample would depend on available resources and time.
        iii. Appropriate sampling weights are calculated for the subsamples as,
        e.g., $w_i = \frac{n_d}{n'_d}$, where w_i is the weight of the ith subplot, n_d is the number of difficult access sites in the ecozone, and n'_d is the size of the subsample.
        iv. Visit the subsample sites to collect measurements following the same sampling procedures as for regular NFI grid locations.
        v. Document the subsamples and the non-sampled difficult locations in the database together with their sampling weights.

Note that the approaches proposed above to handle difficult access sites will produce unbiased totals or means for the ecozone; the penalty will be larger standard errors (due to the reduced sample size).

Partial Plots

NFI ground plots are only established in forested areas and are used to gather detailed information of the site conditions of Canada's forested land base. Ground plots should be measured in full, unless one of the following situations is encountered:

1. Hazardous situation
2. Plot falls partially out of forested polygon

When one or both of these situations is encountered at a plot:

- complete measurements on the non-hazardous, forested portion of the plot;
- map plot, indicating the portion of the plot that was sampled;
- calculate and record the actual measured area of each sub plot and transect in the designated area of the appropriate field card; and

- record the reason why the full plot was not measured in full on the appropriate field card.

Hazardous Situations

Before measuring a ground plot, field crews should assess whether measuring all or a portion of a plot presents a safety concern for crew members. For example, a plot could be near the edge of a cliff, or there may be a wasp nest in the middle of a microplot making clipping in the microplot unsafe. The safety of the field crew should always be the priority.

Decision key for dealing with hazardous situations

1. Determine if the ground plot location is safe to sample.
    a. Sample is safe. Complete the full sample.
    b. Sample is unsafe. Determine where it is safe to sample.
        i. All of sample is unsafe.
            a. Comment on safety issues; record as much data as possible.
            b. Follow guidelines for handling unavailable and difficult access plots.
        ii. Portions of the sample is unsafe.
            a. Map safe portion.
            b. Calculate and record plot areas and transect lengths within the safe area.
            c. Complete measurements in safe area(s).

Partially Forested Plots

Ground plots are established in forested areas. For NFI purposes, forested area refers to land ≥ 10% occupied (by crown cover) by tree species of any size, including young natural stands and all plantations that have yet to reach the minimum crown density. Temporarily non-stocked areas (recent harvests, burned areas) expected to revert to forests (as defined) are included. Where the land cover has been classified as vegetated (see Appendix P), the land should be > 0.5 ha and > 20 m in width with the trees capable of reaching a mature height of 5 m in situ (FAO 2001).

During plot selection, a location was only selected as a ground plot if the plot center fell within a forested polygon. In some cases, a portion of the plot and/or portions of the transects may fall partially out of the forested polygon. If a plot falls partially within a forested polygon and partially in a non-forested polygon, the objective is **not** to measure the entire plot, but to measure and map the portion of the forested polygon within the plot that can be safely sampled.

Appendix D: Handling Unavailable, Difficult Access, and Partial Ground Plot Sites

What is a non-forested area?

For this inventory, a non-forested area is land that does not meet the definition of forested. The land should be < 10% occupied (by crown cover) by tree species (of any size) capable of reaching a mature height of 5 m. Areas that have been cleared for a temporary use, such as logging landings and borrow pits., which are expected to regenerate, are not considered non-forested.

When are non-forested sites to be excluded from sampling?

Two types of non-forested situations will be encountered:

1. Polygonal areas such as lakes, non-treed rock outcrops, non-treed wetlands, cultivated fields, etc.

2. Linear features such as rivers, pipeline right-of-ways, roads, etc.

Polygonal Areas:

To be excluded from the area sampled, a non-forested polygon must be a minimum size of 0.5 ha. Exceptions to the minimum size requirements include areas being actively maintained in a non-forested condition, for example:

- Developed areas with on-site structure(s) (example is communication tower), and the maintained area next to a structure < 0.5 ha.

***Note*: In most cases, the non-forested polygons will be identified from aerial photographs by the project manager, who will obtain the polygon area through GIS data. The sampling crew should have the areas for the non-forested polygons and directions on measuring partial plots as part of the sample package.**

Linear Features:

Except for streams and rivers, a linear feature must have a minimum width of 20 m and a total area > 0.5 ha to be excluded from the area sampled. Exceptions to the minimum size requirements include:

- Improved roads: paved roads, gravel roads, or improved dirt roads regularly maintained for long-term continuing use.

- Maintained rights of way: corridors created for railroads, power lines, gas lines, and canals that are periodically treated to limit the establishment and growth of trees and shrubs. If these right of ways are not regularly being maintained and are reverting to tree cover then they would be sampled.

Linear water features such as streams and rivers are regularly encountered in forest sites. For a linear water feature to be excluded from the area sampled, it and its associated riparian area (measured from where tree cover could become established on each bank above the high water mark) must be > 10 m in width and > 0.5 ha. The linear water feature must meet both criteria (minimum width and area) before it is considered as non-forested.

***Note*: In some cases, it may not be safe to sample across a linear water feature classified as forested. In many cases there is little, if anything to measure in that area and venturing into the water is not required (e.g., unless there is lots of vegetation growing above the surface of the water feature, a full microplot would be recorded with a biomass of zero for each layer). However, if there is something that needs to be measured over the water feature, assess the safety of doing so first. A portion of the plot and/or transect may need to be dropped for safety concerns. This would need to be calculated in the actual area sampled (see hazardous situations).**

After locating ground plot center, the following decision key should be followed for measuring partially forested plots:

Decision key for measuring partially forested plots

1. Determine if the sample is fully forested (see above definition).
   a. Sample is fully forested: Complete Sample.
   b. Portion of sample area is non-forested; determine whether a polygonal area or linear feature is non-forested.
      i. **Polygonal** area is non-forested.
         a. Non-forested polygon area is < 0.5 ha and **not** being regularly maintained in non-forested condition: Include area in forested portion and complete sample in full.
         b. Non-forested polygon area is < 0.5 ha and **is** being regularly maintained in non-forested condition: Exclude area as non-forested
            1. Map forested and non-forested features on cluster plot diagram.
            2. Calculate and record plot areas and transect lengths within the forested area.
            3. Complete all measurements in forested area **only**.
         c. Non-forested polygon area is > 0.5 ha, exclude area as non-forested.
            1. Map forested and non-forested features on cluster plot diagram.
            2. Calculate and record plot areas and transect lengths within the forested area.
            3. Complete all measurements in forested area **only**.
      ii. **Linear** feature is a non-forested area, but not a stream or river.
         a. Linear feature is > 20 m wide and > 0.5 ha, exclude area as non-forested.

1. Map forested and non-forested features on cluster plot diagram.
2. Calculate and record plot areas and transect lengths within the forested area.
3. Complete all measurements in forested area **only**.

b. Linear feature is > 20 m wide and < 0.5 ha, include area in forested portion and complete sample in full.

c. Linear feature is < 20 m wide and not maintained: Include area in forested portion and complete sample in full.

d. Linear feature is < 20 m wide but being maintained in a non-forested condition (e.g., regularly being brushed, mowed, chemically sprayed): Exclude area as non-forested.

1. Map forested and non-forested features on cluster plot diagram.
2. Calculate and record plot areas and transect lengths within the forested area.
3. Complete all measurements in forested area **only**.

iii. **Linear** feature is a stream or river.

a. Watercourse is < 10 m wide: Complete sample measurements through water feature as a forested area.

b. Watercourse is > 10 m wide and > 0.5 ha, exclude the area from the forested sample area.

1. Map the forested and non-forested features on cluster plot diagram.
2. Calculate and record plot areas and transect lengths within the forested area.
3. Complete measurements in the forested area **only**.

Mapping the Partial Plot

The objectives of mapping the forested portion of the plot are:

- To assist in calculating the measured plot areas for the fixed-area circular plots and transects that make up a ground plot. The actual sampled portions would be recorded on the various appropriate field cards.

- To determine the encroachment of the forested or non-forested area in successive measurements.

- To assist returning field crews in remeasurement.

The map of the partially forested plot and/or transects will be recorded on the Cluster Diagram Field Card (Diagram 4). Completely map the entire plot, indicating the location of the portion of the plot that falls in the non-forested area. If possible, map using bearings and distances to the line that divides the forested from the non-forested part of the plot.

Ensure an adequate range of plot photographs are taken to describe and illustrate the non-forest or safety issues encountered on the plot. This may mean taking more than the recommended eight plot photographs.

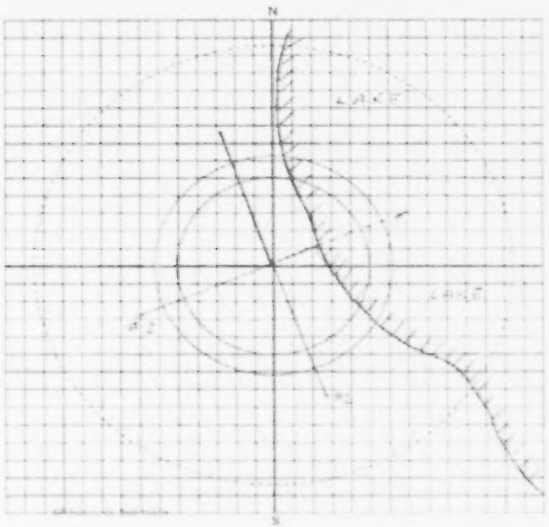


Diagram 23 Cluster diagram of partial plot.

Where Does the Edge of the Forested or Non-forested Area Begin?

The edge of the forested polygon should be:

- In a forested (treed) polygon, the outside edge of the Dominant and Co-dominant tree boles will form the polygon edge. Minor indentations along the boundary should not be included in the non-forest area.

- In some instances, the edge of the treed forest area will be indistinct where tree cover is gradually encroaching on a non-forested site. The area is forested if there is 10% tree cover. The crew will have to determine this boundary in the field. If the line is not distinct, one approach may be to determine where the area is definitely 10% forested and the area that is definitely not 10% forested. Select and temporarily mark a point half way between the two locations.

- When the forested polygon butts up against a water feature, such as a lake or stream, the normal high water mark will be mapped as the boundary.
- Where the complete sample cannot be accessed due to safety concerns, establish a boundary at a safe distance from the danger area. This boundary would now be the mapped sampling area.

Calculating the Area Sampled on Partial Plots

After mapping the portion of the field plot within the forested area, the crew would calculate the actual sampled area of all the various plots within the sample. The cluster diagram has a square grid, which can be used to calculate the approximate area of the sampled and non-sample portions. Jurisdictions may have their own methods of calculating actual sampled areas.

For example, a portion of the Large Tree Plot falls into a lake, which occupies 25% of the 11.28-m circular Large Tree Plot. The nominal sample area recorded for the Large Tree Plot would be 0.0400 ha. The actual sample area measured would be 75% of the nominal plot area or 0.0300 ha (record this value in the actual sample area field on the large tree card). The same lake may also cover 10% of the small tree and stump plot. The actual area sampled for the small tree and stump plots would be 0.0045 (90% of nominal plot size of 0.0050 ha). The ecology sampling plot areas would be determined in the same fashion. The woody debris and surface substrate transects may also be shortened, as they extend into the lake. Record the lengths of the transects sampled on the appropriate field cards and map on the Cluster card. The microplots would be dropped on these transects if they fall out of the forested polygon.

In some situations, the sampling crew will not have the areas for non-forested sites, as a "new" non-forest polygon is encountered in the field or it was overlooked in the sample preparations. In these cases, the crew must calculate the approximate area of the non-forested site to determine if the area is to be excluded from sampling. For example:

A non-forested wetland occupies a portion of the large tree sample plot. The wetland is approximately 150 m in length and 50 m in width, which occupies 0.75 ha (150 × 50 m = 7500 m^2/10 000 m^2 = 0.75 ha). This non-forest polygon is > 0.5 ha; therefore, it will be excluded from the sampling area.

A non-forested wetland occupies a portion of the large tree sample plot. The wetland is approximately 50 m in length and 30 m in width, which occupies 0.15 ha (50 × 30 m = 1500 m^2/10 000 m^2 = 0.15 ha). This non-forest polygon is < 0.5 ha; therefore, it will be included with the sampling area.

***Note*:** Both of these areas would be mapped on the cluster card diagram even though one is sampled while the other area is excluded from sampling.

Recording of Plot Data

Once the forested portion of the sample has been identified, the data collected in the forested portion is completed as one record even though there may be mature forest on one side of the sample plot and immature trees encroaching on a former non-forested site on the other edge of the plot. All data relate to the plot center.

For each sampling component, record on the tally card the area or length of transect that was completely sampled. In the comments section of each field card, note why the rest of the plot was not sampled. For example, if only the first 20.0 m of the woody debris

transect was sampled because the other 10.0 m of a transect extends into a non-forested wetland, record 20 m of 30 m of CWD completed. In the comments section, record the reason a portion of the line transect was not measured

Appendix E: NFI Tree Species List (version 4.1, September 2007)

The following is a list of tree species as recognized for the National Forest Inventory. The species on this list meet the definition for a "tree" in this inventory: a woody plant, usually with a single stem and definite crown that can reach a mature height of 5.0 m somewhere within its natural range.

1. Native Conifers

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
amabilis fir	Abies amabilis	ABIE	AMA		
balsam fir	Abies balsamea	ABIE	BAL		
Rocky Mountain alpine fir	Abies bifolia	ABIE	BIF		
grand fir	Abies grandis	ABIE	GRA		
subalpine fir	Abies lasiocarpa	ABIE	LAS		
unidentified fir	Abies spp.	ABIE	SPP		
yellow-cedar	Chamaecyparis nootkatensis	CHAM	NOO		
unidentified cypress	Chamaecyparis spp.	CHAM	SPP		
unidentified softwood		**GENC**	**SPP**		
Rocky mountain juniper	Juniperus scopulorum	JUNI	SCO		T/S
unidentified juniper	Juniperus spp.	JUNI	SPP		
Eastern redcedar	Juniperus virginiana	JUNI	VIR		T/S
tamarack	Larix laricina	LARI	LAR		
subalpine larch	Larix lyallii	LARI	LYA		
Western larch	Larix occidentalis	LARI	OCC		
unidentified larch	Larix spp.	LARI	SPP		
Engelmann spruce	Picea engelmannii	PICE	ENG		
Engelmann x white	Picea engelmannii x glauca	PICE	ENG	GLA	
white spruce	Picea glauca	PICE	GLA		
Sitka x white	Picea x lutzii	PICE	LUT	X	
black spruce	Picea mariana	PICE	MAR		
red spruce	Picea rubens	PICE	RUB		
Sitka spruce	Picea sitchensis	PICE	SIT		
Sitka x unidentified	Picea sitchensis x unknown	PICE	SIT	X	
unidentified spruce	Picea spp.	PICE	SPP		

Native Conifers (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
whitebark pine	Pinus albicaulis	PINU	ALB		
jack pine	Pinus banksiana	PINU	BAN		
lodgepole pine	Pinus contorta	PINU	CON		
shore pine	Pinus contorta var. contorta	PINU	CON	CON	
lodgepole pine	Pinus contorta var. latifolia	PINU	CON	LAT	
limber pine	Pinus flexilis	PINU	FLE		
Western white pine	Pinus monticola	PINU	MON		
lodgepole x jack pine	Pinus x murraybanksiana	PINU	MUR		
Ponderosa pine	Pinus ponderosa	PINU	PON		
red pine	Pinus resinosa	PINU	RES		
pitch pine	Pinus rigida	PINU	RIG		
unidentified pine	Pinus spp.	PINU	SPP		
eastern white pine	Pinus strobus	PINU	STR		
Douglas-fir	Pseudotsuga menziesii	PSEU	MEN		
Interior Douglas-fir	Pseudotsuga menziesii var. glauca	PSEU	MEN	GLA	
Coastal Douglas-fir	Pseudotsuga menziesii var. menziesii	PSEU	MEN	MEN	
western yew	Taxus brevifolia	TAXU	BRE		
unidentified yew	Taxus spp.	TAXU	SPP		
eastern white-cedar	Thuja occidentalis	THUJ	OCC		
western redcedar	Thuja plicata	THUJ	PLI		
unidentified thuja	Thuja spp.	THUJ	SPP		
eastern hemlock	Tsuga canadensis	TSUG	CAN		
western hemlock	Tsuga heterophylla	TSUG	HET		
mountain hemlock	Tsuga mertensiana	TSUG	MER		
mountain x western hemlock hybrid	Tsuga mertensiana x heterophylla	TSUG	MER	HET	
unidentified hemlock	Tsuga spp.	TSUG	SPP		

* ***Notes:*** "x" denotes hybridization.

T/S **Tree/Shrub:** Some woody species can have a form resembling a tree on some sites, while on other sites they more closely resemble a shrub. For the above species, coded "T/S", the sampling crew should refer to the local jurisdiction plant list to determine whether the species should be measured as a tree or a shrub.

2. Native Hardwoods

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
vine maple	Acer circinatum	ACER	CIR		T/S
Douglas maple	Acer glabrum var. douglasii	ACER	GLA	DOU	T/S
bigleaf maple	Acer macrophyllum	ACER	MAC		
Manitoba maple (box-elder)	Acer negundo	ACER	NEG		
black maple	Acer nigrum	ACER	NIG		
striped maple	Acer pennsylvanicum	ACER	PEN		
red maple	Acer rubrum	ACER	RUB		
silver maple	Acer saccharinum	ACER	SAC		
sugar maple	Acer saccharum	ACER	SAH		
mountain maple	Acer spicatum	ACER	SPI		T/S
mountain alder	Alnus incana ssp. tenuifolia	ALNU	INC	TEN	
red alder	Alnus rubra	ALNU	RUB		
speckled alder	Alnus rugosa	ALNU	RUG		T/S
hazel alder	Alnus serrulata	ALNU	SER		T/S
Sitka alder	Alnus sinuata	ALNU	SIN		T/S
unidentified alder	Alnus spp.	ALNU	SPP		
Siberian alder	Alnus viridis ssp. fruticosa	ALNU	VIR	FRU	T/S
Sitka alder	Alnus viridis ssp. sinuata	ALNU	VIR	SIN	T/S
Saskatoon-berry	Amelanchier alnifolia	AMEL	ALN		T/S
downy serviceberry	Amelanchier arborea	AMEL	ARB		T/S
mountain serviceberry	Amelanchier bartramiana	AMEL	BAR		T/S
Pacific serviceberry	Amelanchier florida	AMEL	FLO		T/S
smooth juneberry	Amelanchier laevis	AMEL	LAE		T/S
roundleaf juneberry	Amelanchier sanguinea	AMEL	SAN		T/S
unidentified serviceberry	Amelanchier spp.	AMEL	SPP		
arbutus	Arbutus menziesii	ARBU	MEN		
unidentified asimina	Asimina	ASIM	SPP		
pawpaw	Asimina triloba	ASIM	TRI		
Alaska paper birch	Betula alaskana	BETU	ALA		
yellow birch	Betula alleghaniensis	BETU	ALL		
blueleaf birch	Betula x caerulea	BETU	CAE		

Native Hardwoods (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
mountain paper birch	Betula cordifolia	BETU	COR		
Kenai birch	Betula kenaica	BETU	KEN		
cherry birch	Betula lenta	BETU	LEN		
Alaska paper birch	Betula neoalaskana	BETU	NEO		
water birch	Betula occidentalis	BETU	OCC		
white birch	Betula papyrifera	BETU	PAP		
Alaska paper birch	Betula papyrifera var. neoalaskana	BETU	PAP	NEO	
white birch	Betula papyrifera var. papyrifera	BETU	PAP	PAP	
gray birch	Betula populifolia	BETU	POP		
unidentified birch	Betula spp.	BETU	SPP		
Alaska x paper birch hybrid	Betula x winteri	BETU	WIN		
blue-beech	Carpinus caroliniana	CARP	CAR		
unidentified hornbeam	Carpinus spp.	CARP	SPP		
bitternut hickory	Carya cordiformis	CARY	COR		
red hickory	Carya glabra var. odorata	CARY	GLA	ODO	
shellbark hickory	Carya liciniosa	CARY	LAC		
shagbark hickory	Carya ovata	CARY	OVA		
unidentified hickory	Carya spp.	CARY	SPP		
mockernut	Carya tomentosa	CARY	TOM		
unidentified maple	Acer spp.	ACER	SPP		
Ohio buckeye	Aesculus glabra	AESC	GLA		
gray alder	Alnus incana	ALNU	INC		T/S
speckled alder	Alnus incana ssp. rugosa	ALNU	INC	RUG	T/S
American chestnut	Castanea dentata	CAST	DEN		
unidentified chestnut	Castanea spp.	CAST	SPP		
hackberry	Celtis occidentalis	CELT	OCC		
unidentified hackberry	Celtis spp.	CELT	SPP		
dwarf hackberry	Celtis tenuifolia	CELT	TEN		T/S
button-bush	Cephalanthus occidentalis	CEPH	OCC		T/S
redbud	Cercis canadensis	CERC	CAN		
alternate-leaf dogwood	Cornus alternifolia	CORN	ALT		T/S

Native Hardwoods (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
eastern flowering dogwood	Cornus florida	CORN	FLO		T/S
Pacific dogwood	Cornus nuttallii	CORN	NUT		
round leaf dogwood	Cornus rugosa	CORN	RUG		T/S
unidentified dogwood	Cornus spp.	CORN	SPP		
redosier dogwood	Cornus stolonifera	CORN	STO		T/S
hawthorn	Crataegus spp.	CRAT	SPP		T/S
silverberry	Elaeagnus commutata	ELAE	COM		T/S
burning-bush euonymus	Euonymus atropurpureus	EUON	ATR		T/S
American beech	Fagus grandifolia	FAGU	GRA		
unidentified beech	Fagus spp.	FAGU	SPP		
white ash	Fraxinus americana	FRAX	AME		
black ash	Fraxinus nigra	FRAX	NIG		
red ash	Fraxinus pennsylvanica	FRAX	PEN		
northern red ash	Fraxinus pennsylvanica var. austini	FRAX	PEN	AUS	
green ash	Fraxinus pennsylvanica var. subintegerrima	FRAX	PEN	SUB	
blue ash	Fraxinus quadrangulata	FRAX	QUA		
unidentified ash	Fraxinus spp.	FRAX	SPP		
unidentified hardwood		**GENH**	**SPP**		
honey-locust	Gleditsia triacanthos	GLED	TRI		
Kentucky coffeetree	Gymnocladus dioicus	GYMN	DIO		
witch-hazel	Hamamelis virginiana	HAMA	VIR		T/S
unidentified holly	Ilex spp.	ILEX	SPP		T/S
common winterberry	Ilex verticillata	ILEX	VER		T/S
butternut	Juglans cinerea	JUGL	CIN		
black walnut	Juglans nigra	JUGL	NIG		
unidentified walnut	Juglans spp.	JUGL	SPP		
northern spicebush	Lindera benzoin	LIND	BEN		
unidentified liriodendron	Liriodendron spp.	LIRI	SPP		
tulip-tree	Liriodendron tulipifera	LIRI	TUL		
cucumber-tree	Magnolia acuminata	MAGN	ACU		
wild crab apple	Malus coronaria	MALU	COR		
Pacific crab apple	Malus fusca	MALU	FUS		

Native Hardwoods (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
unidentified apple	Malus spp.	MALU	SPP		
red mulberry	Morus rubra	MORU	RUB		
Pacific bayberry	Myrica californica	MYRI	CAL		T/S
mountain-holly	Nemopanthus mucronatus	NEMO	MUC		T/S
unidentified nemopanthus	Nemopanthus spp.	NEMO	SPP		T/S
tupelo	Nyssa spp.	NYSS	SPP		
black-gum	Nyssa sylvatica	NYSS	SYL		
unidentified hop-hornbeam	Ostrya spp.	OSTR	SPP		
ironwood (hop-hornbeam)	Ostrya virginiana	OSTR	VIR		
sycamore	Platanus occidentalis	PLAT	OCC		
unidentified sycamore	Platanus spp.	PLAT	SPP		
narrowleaf cottonwood	Populus angustifolia	POPU	AGU		
balsam poplar	Populus balsamifera	POPU	BAL		
balsam poplar	Populus balsamifera ssp balsamifera	POPU	BAL	BAL	
eastern cottonwood	Populus deltoides	POPU	DEL		
eastern cottonwood	Populus deltoides ssp. deltoides	POPU	DEL	DEL	
southern (or plains) cottonwood	Populus deltoides ssp. monilifera	POPU	DEL	MON	
largetooth aspen	Populus grandidentata	POPU	GRA		
Jack's hybrid poplar	Populus x jackii	POPU	JAC		
hybrid poplars	Populus spp.	POPU	SPP		
unidentified poplar	Populus spp.	POPU	SPP		
trembling aspen	Populus tremuloides	POPU	TRE		
black cottonwood	Populus trichocarpa	POPU	TRI		
bitter cherry	Prunus emarginata	PRUN	EMA		
Canada plum	Prunus nigra	PRUN	NIG		
pin cherry	Prunus pennsylvanica	PRUN	PEN		
black cherry	Prunus serotina	PRUN	SER		
unidentified cherry	Prunus spp.	PRUN	SPP		
choke cherry	Prunus virginiana	PRUN	VIR		T/S
choke cherry	Prunus virginiana var. virginiana	PRUN	VIR	VIR	T/S

Native Hardwoods (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
common hoptree	Ptelea trifoliata	PTEL	TRI		
white oak	Quercus alba	QUER	ALB		
swamp white oak	Quercus bicolor	QUER	BIC		
northern pin oak	Quercus ellipsoidalis	QUER	ELL		
Garry oak	Quercus garryana	QUER	GAR		
bur oak	Quercus macrocarpa	QUER	MAC		
Chinquapin oak	Quercus muehlenbergii	QUER	MUE		
pin oak	Quercus palustris	QUER	PAL		
dwarf Chinquapin oak	Quercus prinoides	QUER	PRI		T/S
red oak	Quercus rubra	QUER	RUB		
Shumard oak	Quercus shumardii	QUER	SHU		
unidentified oak	Quercus spp.	QUER	SPP		
black oak	Quercus velutina	QUER	VEL		
common buckthorn	Rhamnus cathartica	RHAM	CAT		T/S
cascara buckthorn	Rhamnus purshiana	RHAM	PUR		
unidentified buckthorn	Rhamnus spp.	RHAM	SPP		
unidentified sumac	Rhus spp.	RHUS	SPP		T/S
staghorn sumac	Rhus typhina	RHUS	TYP		T/S
black locust	Robinia pseudoacacia	ROBI	PSE		
unidentified robinia	Robinia spp.	ROBI	SPP		
peachleaf willow	Salix amygdaloides	SALI	AMY		
Bebb willow	Salix bebbiana	SALI	BEB		T/S
pussy willow	Salix discolor	SALI	DIS		T/S
shining willow	Salix lucida	SALI	LUC		T/S
Pacific willow	Salix lucida ssp. lasiandra	SALI	LUC	LAS	T/S
shining willow	Salix lucida ssp. lucida	SALI	LUC	LUC	T/S
McCalla's willow	Salix maccalliana	SALI	MAC		
black willow	Salix nigra	SALI	NIG		
meadow willow	Salix petiolaris	SALI	PET		T/S
diamond leaf willow	Salix planifolia	SALI	PLA		T/S
Balsam willow	Salix pyrifolia	SALI	PYR		T/S
Scouler willow	Salix scouleriana	SALI	SCO		T/S
Sitka willow	Salix sitchensis	SALI	SIT		T/S

Native Hardwoods (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
unidentified willow	Salix spp.	SALI	SPP		T/S
red-berry elder	Sambucus callicarpa	SAMB	CAL		T/S
American elder	Sambucus canadensis	SAMB	CAN		T/S
blue-berry elder	Sambucus cerulea	SAMB	CER		T/S
sassafras	Sassafras albidum	SASS	ALB		
unidentified sassafras	Sassafras	SASS	SPP		
silver buffalo-berry	Shepherdia argentea	SHEP	ARG		T/S
American mountain-ash	Sorbus americana	SORB	AME		T/S
showy mountain-ash	Sorbus decora	SORB	DEC		
mountain-ash	Sorbus spp.	SORB	SPP		
Basswood	Tilia americana	TILI	AME		
unidentified linden	Tilia spp.	TILI	SPP		
poison-sumac	Toxicodendron vernix	TOXI	VER		T/S
white elm	Ulmus americana	ULMU	AME		
red elm	Ulmus rubra	ULMU	RUB		
unidentified elm	Ulmus spp.	ULMU	SPP		
rock elm	Ulmus thomasii	ULMU	THO		
northern wild-raisin (withe-rod)	Viburnum cassinoides	VIBU	CAS		T/S
nannyberry	Viburnum lentago	VIBU	LEN		T/S
viburnum	Viburnum spp.	VIBU	SPP		T/S
common prickly-ash	Zanthoxylum americanum	ZANT	AME		T/S

* ***Notes:*** "x" denotes hybridization

T/S **Tree/Shrub:** Some woody species can have a form resembling a tree on some sites, while on other sites it more closely resembles a shrub. For the above species, coded "T/S", the sampling crew should refer to the local jurisdiction plant list to determine whether the species should be measured as a tree or a shrub.

3. Exotics

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
white fir	Abies concolor	ABIE	CON		
red fir	Abies magnifica	ABIE	MAG		
Shasta red fir	Abies magnifica var. shastensis	ABIE	MAG	SHA	
Nordmann fir	Abies nordmanniana	ABIE	NOR		
Spanish fir	Abies pinsapo	ABIE	PIN		
noble fir	Abies procera	ABIE	PRO		
Amur maple	Acer ginnala	ACER	GIN		T/S
Japanese maple	Acer palmatum	ACER	PAL		T/S
Norway maple	Acer platanoides	ACER	PLA		
sycamore maple	Acer pseudoplatanus	ACER	PSE		
red horsechestnut	Aesculus x carnea	AESC	CAR		
horsechestnut	Aesculus hippocastanum	AESC	HIP		
ailanthus	Ailanthus altissima	AILA	ALT		
European black alder	Alnus glutinosa	ALNU	GLU		
Japanese angelica-tree	Aralia elata	ARAL	ELA		
monkey puzzle	Araucaria araucana	ARAU	ARA		
European white birch	Betula pendula	BETU	PEN		
silver (downy) birch	Betula pubescens	BETU	PUB		
incense cedar	Calocedrus decurrens	CALO	DEC		
Siberian pea-tree	Caragana arborescens	CARA	ARB		T/S
Chinese chestnut	Castanea mollissima	CAST	MOL		
southern catalpa	Catalpa bignonioides	CATA	BIG		
northern catalpa	Catalpa speciosa	CATA	SPE		
Atlas cedar	Cedrus atlantica	CEDR	ATL		
Deodar cedar	Cedrus deodara	CEDR	DEO		
Cedar-of-Lebanon	Cedrus libani	CEDR	LIB		
Katsura-tree	Cercidiphyllum japonicum	CERC	JAP		
Port-Orford-cedar	Chamaecyparis lawsoniana	CHAM	LAW		
Hinoki-cypress	Chamaecyparis obtusa	CHAM	OBT		
Sawara-cypress	Chamaecyparis pisifera	CHAM	PIS		
Yellow-wood	Cladrastis lutea	CLAD	LUT		
Kousa dogwood	Cornus kousa	CORN	KOU		

Exotics (continued)

Common Name	Scientific Name	Code			
		Genus	Species	Var	Form
Cornelian cherry	Cornus mas	CORN	MAS		
European beech	Fagus sylvatica	FAGU	SYL		
Oregon ash	Fraxinus latifolia	FRAX	LAT		
unidentified exotic		GENX	SPP		
Ginkgo	Ginkgo biloba	GINK	BIL		
European larch	Larix decidua	LARI	DEC		
Japanese larch	Larix kaempferi	LARI	KAE		
Siberian larch	Larix sibirica	LARI	SIB		
Norway spruce	Picea abies	PICE	ABI		
Colorado spruce	Picea pungens	PICE	PUN		
sugar pine	Pinus lambertiana	PINU	LAM		
Austrian pine	Pinus nigra	PINU	NIG		
Monterey pine	Pinus radiata	PINU	RAD		
Scots pine	Pinus sylvestris	PINU	SYL		
European white poplar	Populus alba	POPU	ALB		
Lombardy poplar	Populus nigra	POPU	NIG		
sweet cherry	Prunus avium	PRUN	AVI		
common pear	Pyrus communis	PYRU	COM		
English oak	Quercus robur	QUER	ROB		
Weeping willow	Salix alba var. vitellina	SALI	ALB	VIT	
giant sequoia	Sequoiadendron giganteum	SEQU	GIG		
coast redwood	Sequoia sempervirens	SEQU	SEM		
European mountain-ash	Sorbus aucuparia	SORB	AUC		
Common lilac	Syringa vulgaris	SYRI	VUL		T/S
English yew	Taxus baccata	TAXU	BAC		
Siberian elm	Ulmus pumila	ULMU	PUM		
European cranberry viburnum	Viburnum opulus	VIBU	OPU		T/S

* ***Notes***: "x" denotes hybridization.

T/S **Tree/Shrub:** Some woody species can have a form resembling a tree on some sites, while on other sites they more closely resemble a shrub. For the above species, coded "T/S", the sampling crew should refer to the local jurisdiction plant list to determine whether the species should be measured as a tree or a shrub.

Appendix F: Equipment List

Item Number	Qty	Item	Plot navigation	Plot photographs	Small and coarse woody debris	Surface substrate	Ecological Information	Soil pit and horizon information	Microplots – clipping	Microplots - fine woody debris	Microplots - forest floor organic samples	Microplots - soil bulk density samples	Large tree information	Small tree information	Shrub information	Stump Information	Ground plot site information
1	(1)	geographic positioning system (GPS) for measuring UTM coordinates in the field	x														x
2	(1)	clinometer for measuring slope, tree heights and tilt angle of CWD			x								x	x			x
3	(2)	compass for measuring aspect, azimuths, transect orientation, and for stem mapping	x		x	x							x				x
4	(1)	tight chain	x														
5		mid-scale (e.g., 1 to 20 000) aerial photos of plot	x														
6		forest cover area map of plot	x														
7	(1)	large axe for blazing tree	x														
8		historical site information or management records for assessing disturbance and mortality															x
9		historical site information or management records for assessing vegetation and regeneration															x
10		historical site information or management records for measuring treatment															x
11	(2)	30.0-m tapes (or 50 m on sloping terrain) for laying out line transects and plots			x	x	x		x	x	x	x	x	x	x	x	

Item Number	Qty	Item	Plot navigation	Plot photographs	Small and coarse woody debris	Surface substrate	Ecological Information	Soil pit and horizon information	Microplots – clipping	Microplots - fine woody debris	Microplots - forest floor organic samples	Microplots - soil bulk density samples	Large tree information	Small tree information	Shrub information	Stump Information	Ground plot site information
12		flagging tape (at least two colors)	x		x		x						x	x	x		
13		logging paint	x		x								x	x			
14	(1)	small woody debris (> 1.0 and ≤ 7.5 cm diameter pieces) aluminum go-no-go tool			x					x					x		
15	(2)	diameter tape	x		x				x				x	x	x	x	
	(1)	calipers			x											x	
16	(1)	plumb bob (optional) for measuring which woody debris falls under the transect			x												
17	many	paper grocery bags for collecting clipped shrub, herb, bryoid, fine woody debris, small stumps, and unknown plant samples					x		x	x							
18	(1)	heavy-duty field scissors for clipping samples and specimens					x		x	x	x	x					
19		sample labels (forest floor/ soil, unknown plant, tree core)					x				x	x	x				
20	(1)	premeasured length (0.56 m) of rope for microplot boundary layout							x	x							
21		plant identification field guides for keying out plants					x										
22	(1)	large gardening spade for digging soil pit and measuring depths of surface substrate				x		x				x					
23	(2)	tape measures or other device for measuring heights and depths			x	x	x	x	x		x	x		x	x	x	
24	(1)	premeasured length (3.99 m) of rope for Small Tree, Shrub and Stump Plot layout												x	x	x	

Item Number	Qty	Item	Plot navigation	Plot photographs	Small and coarse woody debris	Surface substrate	Ecological Information	Soil pit and horizon information	Microplots – clipping	Microplots - fine woody debris	Microplots - forest floor organic samples	Microplots - soil bulk density samples	Large tree information	Small tree information	Shrub information	Stump information	Ground plot site information
25	(2)	logger's tapes for Large Tree Plot boundary layout											x				
26		lumber crayon or paint for marking breast height on large trees											x				
27	many	metal tags and nails or other tree number markers											x				
28	(1)	vertex hypsometer (optional) for measuring large tree heights, distances, crown lengths, etc.					x						x	x			
29		large-diameter straws for collecting core samples (supplied)											x				
30	(1)	small stapler for stapling core sample straws											x				
31	(2)	increment borer											x				
32		labels or tags for labeling core samples (supplied)											x				
33	(2)	small ruler for measuring core lengths											x				
34	(1)	long-handled (approx. 50 cm long), stainless steel soup spoon or ladle for bulk density sample extraction										x					
35	(1)	pair heavy-duty clippers for cutting roots, fine woody debris						x	x	x	x	x					
36	(1)	stainless steel folding hand saw for cutting forest floor organic layer and roots/stems						x	x		x						
37	(2)	heavy-duty trowels, one with a narrow blade and one with a wider blade for bulk density extraction										x					

Item Number	Qty	Item	Plot navigation	Plot photographs	Small and coarse woody debris	Surface substrate	Ecological information	Soil pit and horizon information	Microplots – clipping	Microplots - fine woody debris	Microplots - forest floor organic samples	Microplots - soil bulk density samples	Large tree information	Small tree information	Shrub information	Stump Information	Ground plot site information
38	(1)	stainless steel ruler, 45 cm or tape measure for measuring bulk density/forest floor organics extraction				x					x	x		x			
39	(1)	plastic, 1.0-L graduated cylinder for measuring bulk density volume										x					
40	(1)	plastic, 100-mL graduated cylinder for measuring bulk density volume										x					
41		5-mm plastic bags for lining excavated hole of bulk density extraction										x					
42		10-mm plastic bags for collecting extracted soil samples, forest floor organic samples									x	x					
43	(2)	liters, 3-mm glass beads in plastic bottles with lids for measuring bulk density extraction volumes										x					
44	(1)	20 x 20 cm (inside dimensions) aluminum template for cutting forest floor organic sample									x	x					
45	(1)	sharp field knife for cutting humus and fine roots, woody debris decay class			x			x			x	x					
46	(1)	flashlight or headlamp, useful for dark soil pits/site conditions (optional)						x				x					
47	(1)	knee pad (optional)						x	x	x	x	x					
48	(1)	small plastic funnel for pouring beads back into container (optional)										x					
49	(1)	camera (digital or film) for taking plot photographs		x													
50		soil sieves						x									

Item Number	Qty	Item	Plot navigation	Plot photographs	Small and coarse woody debris	Surface substrate	Ecological information	Soil pit and horizon information	Microplots – clipping	Microplots - fine woody debris	Microplots - forest floor organic samples	Microplots - soil bulk density samples	Large tree information	Small tree information	Shrub information	Stump Information	Ground plot site information
51		water for soil texturing						x									
52		pens and pencils	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
53	(2)	aluminum field clipboard	x	x	x	x	x	x	x	x	x	x	x	x			x
54	(1)	breast height pole (may be cut from sapling in field)							x				x	x	x	x	
55	(1)	pre-numbered, aluminum tags											x				
56	(1)	aluminum nails											x				
57	many	pigtail pins			x												
58	many	field cards	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
59	(1)	extendable soil probe for deep organic soil (500 cm long)				x											
60		Field manual and/or cheat sheets for instructions and codes	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
61	(1)	Whiteboard		x													
62		Dry erasor		x													

Appendix G: Photo Release Form

Photo Release Form

I, _____, provide my consent for the publication of photographs and captions containing my name and image by Canada's National Forest Inventory. I understand that this may include online publication via Internet and/or Intranet, as well as printed media. I also understand that no fee or royalty shall be due to me for this use of my name and image. As well, I understand that these images may also be distributed for use upon request, subject to the approval of Canada's National Forest Inventory.

Autorisation de publication de photographie

Je, _____, donne mon consentement pour la publication de photographies et de légendes contenant mon nom et mon image par la Direction générale des communications de Ressources naturelles Canada. Je suis conscient que ceci peut inclure la publication électronique au moyen d'Internet et/ou de l'intranet ainsi que la parution dans des documents imprimés. Je suis également conscient que je ne pourrai réclamer aucuns frais ou redevances ayant trait à l'utilisation de mon nom et de mon image. Je comprends que ces images peuvent également être utilisées sur demande, sous réserve d'approbation de la Direction des communications de Ressources naturelles Canada.

Signed / Signé,

_____ _____

(Name / Nom) **(Date)**

(___) _____

(Telephone number / Numéro de téléphone)

_____

(Title / Titre)

_____

(Location / Lieu)

Return or fax to / Retourner ou envoyer par télécopieur à :

Mark Gillis, R.P.F.
Manager, National Forest Inventory / Gestionnaire, Inventaire forestier national
Natural Resources Canada / Ressources naturelles Canada
Government of Canada / Gouvernement du Canada
506 West Burnside Road / 506 chemin Burnside ouest
Victoria, BC V8Z 1M5
Fax: (250) 363-0775

Appendix H: Randomized Numbers

The following random number tables for establishing woody debris transects were developed for the *National Forest Inventory – British Columbia Change Monitoring Procedures for Provincial and National Reporting* and are reprinted with their kind permission.

Seeds 1 to 50	Random Starting	Random Starting + 50	Randomized numbers 1 - 20 (left to right)																			Randomized numbers from 1 to 100 (top to bottom)
01	23	113	14	12	18	8	20	7	19	3	10	15	11	13	16	5	1	17	6	2	9	4	58
02	155	245	1	11	17	13	16	8	5	20	9	2	14	6	12	15	10	4	19	7	3	18	7
03	350	80	4	5	7	19	17	20	2	9	11	14	18	3	6	10	1	8	12	13	15	16	38
04	296	26	1	7	4	15	6	10	20	13	2	17	12	18	19	5	16	14	3	9	8	11	85
05	8	98	17	1	5	19	8	11	9	15	4	13	6	12	10	7	3	18	20	2	16	14	36
06	304	34	18	7	2	1	14	3	5	4	11	15	8	9	20	17	10	12	19	16	6	13	33
07	351	81	10	6	1	13	9	8	11	17	19	3	16	20	5	4	15	18	2	12	7	14	53
08	158	248	19	4	16	20	2	11	10	8	5	13	12	1	14	15	9	6	17	18	7	3	78
09	139	229	14	11	5	2	18	7	19	16	13	1	20	3	4	6	9	17	12	10	8	15	40
10	33	123	17	15	14	18	5	1	7	19	2	6	3	8	9	4	10	20	13	16	12	11	56
11	264	354	15	3	11	20	1	10	19	4	12	5	16	7	18	6	14	2	17	8	9	13	32
12	278	8	5	8	16	6	7	17	11	9	15	14	19	20	10	3	2	12	4	13	18	1	87
13	137	227	2	10	5	15	12	20	17	4	1	13	14	18	9	16	19	8	11	3	6	7	83
14	243	333	14	5	3	4	1	10	15	13	19	20	2	12	11	7	16	6	8	18	17	9	67
15	176	266	15	7	19	11	9	6	8	3	12	10	14	1	2	4	18	5	16	13	17	20	18
16	267	357	19	16	3	7	17	1	20	2	12	15	18	8	11	9	4	14	6	13	10	5	31
17	214	304	6	7	12	14	3	16	8	13	1	20	19	2	5	9	10	15	18	11	4	17	75
18	229	319	13	8	12	18	14	19	15	3	5	20	4	11	1	17	16	6	9	2	19	7	79
19	257	347	17	5	19	12	8	18	3	2	15	16	4	6	20	14	9	10	13	11	7	1	89
20	324	54	14	8	15	4	6	19	16	1	12	2	17	3	18	11	20	5	9	13	18	7	96
21	98	188	18	16	19	15	1	8	18	14	9	11	4	2	12	7	13	17	5	6	20	3	12
22	70	160	15	19	14	1	6	18	12	4	2	5	9	17	20	16	3	10	11	7	13	8	14
23	161	251	9	10	14	18	17	15	4	2	11	16	7	12	6	8	20	1	19	13	5	3	6
24	199	289	5	4	12	1	7	10	20	14	19	9	15	11	16	18	3	13	8	2	17	6	72
25	329	59	14	9	7	3	17	15	18	1	4	16	6	10	12	20	19	2	5	8	13	11	63
26	110	200	20	11	9	13	15	6	2	8	7	10	4	14	18	12	3	17	18	16	1	5	45
27	127	217	5	4	9	15	18	2	19	16	17	11	1	20	8	13	3	12	10	6	7	14	41
28	253	343	3	2	10	14	15	19	6	13	18	5	4	20	8	1	9	16	7	12	17	11	69
29	314	44	5	3	18	14	1	6	2	13	10	20	4	8	15	9	16	19	11	17	12	7	66
30	285	15	20	10	11	14	15	18	17	9	2	7	1	3	5	19	8	13	16	4	12	6	48
31	87	177	5	6	13	7	12	1	20	4	2	14	11	15	9	3	16	17	19	8	18	10	27
32	277	7	2	1	8	14	18	9	7	12	20	15	19	4	6	3	5	17	16	10	11	13	47
33	109	199	14	5	20	2	10	4	18	15	13	9	16	19	1	11	3	17	12	6	7	8	26
34	332	62	7	13	19	9	18	16	11	2	3	6	5	4	20	14	15	8	1	12	17	19	99
35	67	157	3	10	11	15	2	14	7	8	19	18	16	5	17	13	12	6	1	4	20	9	74
36	74	164	2	10	13	6	14	1	5	7	12	19	18	3	17	11	4	15	8	20	16	9	73
37	283	13	16	13	19	14	1	15	12	18	6	7	5	20	9	17	2	3	4	8	10	11	10
38	32	122	18	16	20	10	17	5	12	4	15	14	11	9	7	1	2	3	6	13	8	19	59
39	270	6	5	12	19	20	11	7	10	2	15	3	14	17	4	6	8	16	13	9	18	1	77
40	339	89	13	3	15	2	18	10	11	12	17	16	7	14	4	20	19	9	6	1	5	8	46
41	300	30	10	16	1	12	17	4	19	8	15	20	5	18	14	13	6	7	3	2	11	9	57
42	17	107	16	2	4	1	3	8	9	7	5	12	17	15	19	20	11	6	10	13	14	18	93
43	144	234	6	2	20	19	17	15	12	5	3	18	14	4	9	8	16	1	13	7	11	10	16
44	271	1	16	4	7	1	10	19	8	14	17	13	6	9	11	20	18	5	15	12	2	3	61
45	248	338	20	13	19	5	15	2	10	16	6	12	18	1	3	14	17	8	11	4	7	9	68
46	77	167	2	3	13	20	15	11	17	1	4	7	18	5	6	19	14	9	8	16	12	10	42
47	43	133	11	2	14	12	10	17	18	20	13	15	5	9	4	7	19	3	9	1	16	6	37
48	223	313	7	16	4	20	15	3	2	18	6	11	19	13	1	8	10	12	9	17	5	14	2
49	122	212	10	1	5	7	9	3	16	18	8	13	11	17	19	12	15	20	2	6	14	4	50
50	66	156	19	2	5	17	16	12	8	15	4	14	18	1	11	20	13	3	7	6	9	10	11

FS 505-N2 HRI 00/03

Seeds 1 to 99	Random Bearing	Random Bearing + 90	Randomized numbers 1 - 20 (left to right)																			Randomized numbers from 1 to 100 (top to bottom)
51	45	135	14	17	12	1	10	7	20	16	15	3	6	4	5	13	11	9	8	18	19	2	91
52	27	117	12	7	11	13	8	6	16	20	3	10	14	5	4	1	2	18	9	15	17	19	94
53	13	103	19	12	18	8	5	3	15	10	20	16	1	17	7	2	6	14	4	9	13	11	39
54	25	115	11	1	9	19	16	10	4	20	18	2	6	13	3	14	8	12	5	15	17	7	97
55	49	139	9	6	7	17	15	11	18	5	3	2	8	19	14	4	13	10	16	1	20	12	23
56	328	58	2	12	19	8	6	4	16	7	18	14	1	13	3	10	15	5	9	11	20	17	76
57	247	337	19	16	14	7	17	9	4	6	15	20	3	12	11	13	10	1	18	2	8	5	82
58	334	64	14	11	3	20	12	2	5	6	13	10	4	15	19	8	18	9	1	16	17	7	20
59	21	111	20	12	11	1	14	4	19	7	9	18	15	5	8	16	6	17	13	2	10	3	49
60	232	322	2	4	16	14	20	13	11	3	17	7	6	10	9	15	18	1	19	5	8	12	81
61	125	215	13	16	5	9	14	7	17	2	15	18	3	8	12	6	10	4	1	19	20	11	1
62	234	324	4	2	11	18	13	9	5	20	19	16	17	7	1	10	8	15	3	6	14	12	34
63	180	270	20	19	18	3	1	9	15	5	14	2	17	6	10	7	16	11	12	8	4	13	86
64	212	302	20	12	4	3	5	15	2	9	13	14	10	1	19	8	16	11	7	6	18	17	29
65	141	231	4	7	18	14	3	9	16	20	2	5	8	19	13	11	15	12	6	10	17	1	55
66	38	128	17	10	3	5	13	12	19	11	9	2	7	20	15	18	6	14	15	8	1	4	80
67	249	339	7	19	18	13	17	5	16	20	1	4	15	12	3	11	10	8	9	14	6	2	30
68	15	105	17	9	2	13	1	4	20	19	8	18	10	5	3	7	12	11	14	15	6	16	8
69	317	47	8	7	12	14	16	4	17	15	18	10	3	19	11	13	5	2	20	6	9	1	88
70	196	286	16	12	7	20	2	11	5	3	9	15	13	18	4	1	17	19	10	6	14	8	92
71	337	67	17	18	14	5	15	7	19	20	3	13	2	10	11	9	1	12	16	4	6	8	28
72	150	240	7	10	14	2	17	20	19	12	13	8	16	9	11	5	3	18	4	1	6	15	98
73	305	35	5	8	4	3	2	16	9	10	7	15	6	1	19	20	13	11	14	12	18	17	70
74	303	33	17	19	6	1	14	8	12	9	18	20	11	13	15	16	5	4	7	2	10	3	52
75	208	298	6	5	10	1	18	16	3	9	12	19	13	15	2	14	11	17	4	7	20	8	60
76	115	205	12	11	7	3	10	18	1	19	13	20	15	4	9	14	17	8	16	6	5	2	9
77	143	233	1	7	18	8	2	11	19	5	14	12	13	9	10	15	16	17	4	3	20	6	43
78	37	127	15	11	1	8	10	20	9	14	18	17	5	6	4	13	2	16	12	7	19	3	5
79	250	340	18	12	4	15	16	8	14	19	13	2	5	3	11	10	1	9	17	20	6	7	3
80	356	86	10	15	8	19	14	17	4	16	13	9	18	1	11	2	7	6	3	5	20	12	64
81	326	56	12	8	10	15	19	1	20	13	14	18	16	7	2	6	5	9	17	11	4	3	15
82	162	252	2	4	12	17	3	10	1	15	5	18	6	8	19	16	20	11	13	9	14	7	19
83	352	82	7	17	8	2	1	15	3	20	15	18	14	6	12	9	10	4	19	11	13	5	22
84	266	356	6	15	12	17	7	16	8	19	13	4	10	18	14	11	5	1	2	20	3	9	84
85	81	171	15	14	19	1	4	17	10	20	7	11	13	8	5	18	3	12	9	6	2	16	95
86	235	325	9	5	12	19	3	16	14	15	2	20	10	1	7	6	17	18	13	8	11	4	4
87	205	295	2	1	12	10	19	13	15	17	6	18	11	3	14	8	5	15	7	9	4	20	17
88	335	65	5	19	2	14	8	6	13	3	15	12	16	18	4	9	11	17	1	20	10	7	21
89	56	146	6	11	3	12	1	4	5	18	20	14	13	7	17	16	10	15	8	2	19	9	65
90	308	38	13	19	7	18	10	1	4	11	17	12	9	3	5	16	15	8	2	14	20	6	54
91	76	166	14	11	3	1	15	12	18	10	6	9	13	5	16	19	2	17	20	8	7	4	13
92	36	126	13	15	14	19	10	12	1	8	11	4	5	17	18	2	20	9	7	3	16	6	62
93	227	317	12	2	19	11	14	10	16	9	15	3	20	17	18	1	6	7	5	4	13	8	25
94	342	72	20	4	19	11	6	8	9	10	15	16	5	13	7	12	2	14	17	1	18	3	35
95	16	106	19	1	13	9	15	14	5	11	10	16	18	6	17	3	2	20	8	7	12	4	51
96	204	294	13	9	5	7	1	10	17	14	11	8	20	15	18	4	12	16	19	2	3	6	24
97	290	20	19	5	18	8	2	9	3	14	10	4	7	6	1	13	11	15	17	20	12	16	71
98	239	329	11	12	17	13	10	1	14	20	15	6	2	19	8	16	4	9	3	7	18	5	100
99	5	95	10	8	15	1	16	2	12	9	14	5	3	13	11	17	18	4	7	20	19	6	44
00	181	271	1	12	8	14	3	10	6	11	19	20	7	16	2	9	15	4	5	13	18	17	90

How to use this table for determining random bearings: The last two digits of your sample number are the seed number. For example, if the last two numbers of the sample are "59", read down on the first column until encountering number 59. The second column lists the first random bearing (21°) the third column lists the second random bearing at 90° plus (111°). Random numbers are also available for random sample tree selections if needed.

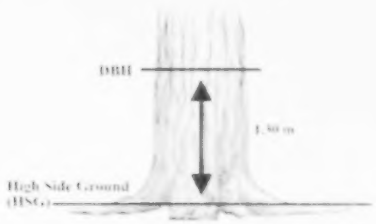
Appendix I: Calculating Slope Allowances

Table courtesy of Cyril Lundrigan (2003). The following table can be used to establish the horizontal radius of the NFI fixed-radius plots on sloping ground. Measure the slope of the ground in percent to a point on the plot radius. Using a measuring tape, mark the slope distances that equate to the horizontal distance. For example, for a slope of 50%, the slope distance for the 5.64-m plot would be 6.31 m, and the slope distance to the 11.28-m plot would be 12.61 m.

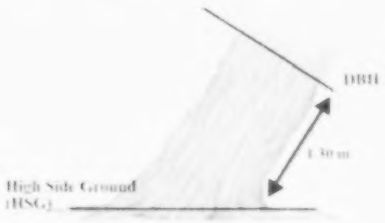
		SLOPE ALLOWANCES										
					Transect Pt							
		Plot Size			7 & 8	6 & 9	5 & 10	4 & 11	3 & 12	2 & 13	1 & 14	0 & 15
% Slope	Factor	5.64	10.00	11.28	1.00	3.00	5.00	7.00	9.00	11.00	13.00	15.00
2	1.000	5.64	10.00	11.28	1.00	3.00	5.00	7.00	9.00	11.00	13.00	15.00
4	0.999	5.64	10.01	11.29	1.00	3.00	5.01	7.01	9.01	11.01	13.01	15.02
6	0.998	5.65	10.02	11.30	1.00	3.01	5.01	7.01	9.02	11.02	13.03	15.03
8	0.997	5.66	10.03	11.32	1.00	3.01	5.02	7.02	9.03	11.03	13.04	15.05
10	0.995	5.67	10.05	11.34	1.01	3.02	5.03	7.04	9.05	11.06	13.07	15.08
12	0.993	5.68	10.07	11.35	1.01	3.02	5.04	7.05	9.06	11.08	13.09	15.11
14	0.990	5.70	10.10	11.39	1.01	3.03	5.05	7.07	9.09	11.11	13.13	15.15
16	0.987	5.71	10.13	11.42	1.01	3.04	5.07	7.09	9.12	11.14	13.17	15.20
18	0.984	5.73	10.16	11.46	1.02	3.05	5.08	7.11	9.15	11.18	13.21	15.24
20	0.981	5.75	10.20	11.50	1.02	3.06	5.10	7.14	9.17	11.21	13.25	15.29
22	0.977	5.77	10.24	11.55	1.02	3.07	5.12	7.16	9.21	11.26	13.31	15.35
24	0.972	5.80	10.28	11.60	1.03	3.09	5.14	7.20	9.26	11.32	13.37	15.43
26	0.968	5.83	10.33	11.66	1.03	3.10	5.17	7.23	9.30	11.36	13.43	15.50
28	0.963	5.86	10.38	11.71	1.04	3.12	5.19	7.27	9.35	11.42	13.50	15.58
30	0.958	5.89	10.44	11.78	1.04	3.13	5.22	7.31	9.39	11.48	13.57	15.66
32	0.952	5.92	10.50	11.84	1.05	3.15	5.25	7.35	9.45	11.55	13.66	15.76
34	0.947	5.96	10.56	11.91	1.06	3.17	5.28	7.39	9.50	11.62	13.73	15.84
36	0.941	5.99	10.63	11.99	1.06	3.19	5.31	7.44	9.56	11.69	13.82	15.94
38	0.935	6.03	10.70	12.07	1.07	3.21	5.35	7.49	9.63	11.76	13.90	16.04
40	0.928	6.07	10.77	12.15	1.08	3.23	5.39	7.54	9.70	11.85	14.01	16.16
42	0.922	6.12	10.85	12.23	1.08	3.25	5.42	7.59	9.76	11.93	14.10	16.27
44	0.915	6.16	10.93	12.32	1.09	3.28	5.46	7.65	9.84	12.02	14.21	16.39
46	0.908	6.21	11.01	12.42	1.10	3.30	5.51	7.71	9.91	12.11	14.32	16.52
48	0.902	6.26	11.09	12.51	1.11	3.33	5.54	7.76	9.98	12.20	14.41	16.63
50	0.894	6.31	11.18	12.61	1.12	3.36	5.59	7.83	10.07	12.30	14.54	16.78
52	0.887	6.36	11.27	12.71	1.13	3.38	5.64	7.89	10.15	12.40	14.66	16.91
54	0.880	6.41	11.36	12.82	1.14	3.41	5.68	7.95	10.23	12.50	14.77	17.05
56	0.873	6.46	11.46	12.93	1.15	3.44	5.73	8.02	10.31	12.60	14.89	17.18
58	0.865	6.52	11.56	13.04	1.16	3.47	5.78	8.09	10.40	12.72	15.03	17.34
60	0.857	6.58	11.66	13.15	1.17	3.50	5.83	8.17	10.50	12.84	15.17	17.50
62	0.850	6.64	11.77	13.27	1.18	3.53	5.88	8.24	10.59	12.94	15.29	17.65
64	0.842	6.70	11.87	13.39	1.19	3.56	5.94	8.31	10.69	13.06	15.44	17.81
66	0.835	6.76	11.98	13.52	1.20	3.59	5.99	8.38	10.78	13.17	15.57	17.96
68	0.827	6.82	12.09	13.64	1.21	3.63	6.05	8.46	10.88	13.30	15.72	18.14
70	0.819	6.88	12.21	13.77	1.22	3.66	6.11	8.55	10.99	13.43	15.87	18.32
72	0.812	6.95	12.32	13.90	1.23	3.69	6.16	8.62	11.08	13.55	16.01	18.47
74	0.804	7.02	12.44	14.03	1.24	3.73	6.22	8.71	11.19	13.68	16.17	18.66
76	0.796	7.08	12.56	14.17	1.26	3.77	6.28	8.79	11.31	13.82	16.33	18.84
78	0.789	7.15	12.68	14.31	1.27	3.80	6.34	8.87	11.41	13.94	16.48	19.01
80	0.781	7.22	12.81	14.45	1.28	3.84	6.40	8.96	11.52	14.08	16.65	19.21
82	0.773	7.29	12.93	14.59	1.29	3.88	6.47	9.06	11.64	14.23	16.82	19.40
84	0.766	7.37	13.06	14.73	1.31	3.92	6.53	9.14	11.75	14.36	16.97	19.58
86	0.758	7.44	13.19	14.88	1.32	3.96	6.60	9.23	11.87	14.51	17.15	19.79
88	0.751	7.51	13.32	15.03	1.33	3.99	6.66	9.32	11.98	14.65	17.31	19.97
90	0.743	7.59	13.45	15.18	1.35	4.04	6.73	9.42	12.11	14.80	17.50	20.19
92	0.736	7.66	13.59	15.33	1.36	4.08	6.79	9.51	12.23	14.95	17.66	20.38
94	0.729	7.74	13.72	15.48	1.37	4.12	6.86	9.60	12.35	15.09	17.83	20.58
96	0.721	7.82	13.86	15.64	1.39	4.16	6.93	9.71	12.48	15.26	18.03	20.80
98	0.714	7.90	14.00	15.79	1.40	4.20	7.00	9.80	12.61	15.41	18.21	21.01
100	0.707	7.98	14.14	15.95	1.41	4.24	7.07	9.90	12.73	15.56	18.39	21.22
102	0.700	8.06	14.28	16.11	1.43	4.29	7.14	10.00	12.86	15.71	18.57	21.43
104	0.693	8.14	14.43	16.27	1.44	4.33	7.22	10.10	12.99	15.87	18.76	21.65
106	0.686	8.22	14.57	16.44	1.46	4.37	7.29	10.20	13.12	16.03	18.95	21.87
108	0.679	8.30	14.72	16.60	1.47	4.42	7.36	10.31	13.25	16.20	19.15	22.09
110	0.673	8.38	14.87	16.77	1.49	4.46	7.43	10.40	13.37	16.34	19.32	22.29
112	0.666	8.47	15.01	16.94	1.50	4.50	7.51	10.51	13.51	16.52	19.52	22.52
114	0.659	8.55	15.16	17.11	1.52	4.55	7.59	10.62	13.66	16.69	19.73	22.76
116	0.653	8.64	15.32	17.28	1.53	4.59	7.66	10.72	13.78	16.85	19.91	22.97
118	0.647	8.72	15.47	17.45	1.55	4.64	7.73	10.82	13.91	17.00	20.09	23.18
120	0.640	8.81	15.62	17.62	1.56	4.69	7.81	10.94	14.06	17.19	20.31	23.44

Appendix J: Measuring Diameters

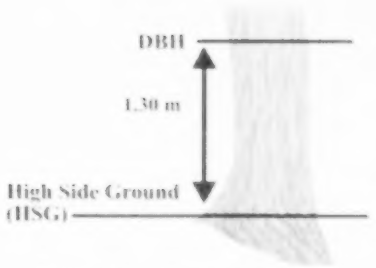
The following diagrams illustrate the procedure to follow when measuring diameter breast height (dbh) at 1.30 m on trees in various positions. The intent at all times is to attain a diameter that best reflects the tree volume. These diagrams are modified from the *U.S. Forest Inventory and Analysis - National Core Field Guide* (2005) and *the National Forest Inventory* (NFI) Ontario (2007) procedures.



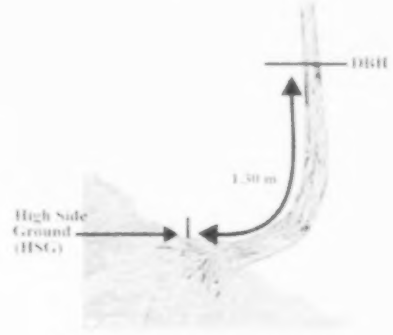
Example 1 **Measuring dbh from high side ground.**



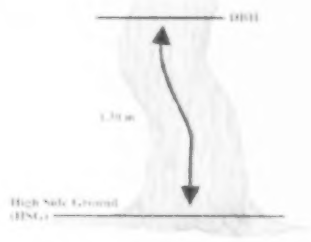
Example 2 **Measuring dbh on leaning trees on level ground.**



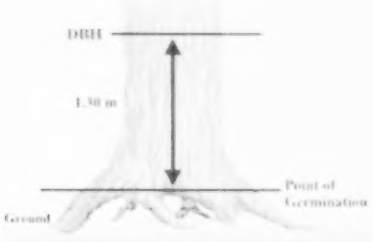
Example 3 **Measuring dbh on sloping ground from high side.**



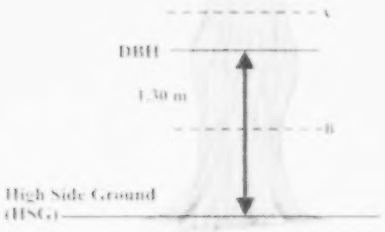
Example 4 **Measuring dbh on curved stems on a slope.**



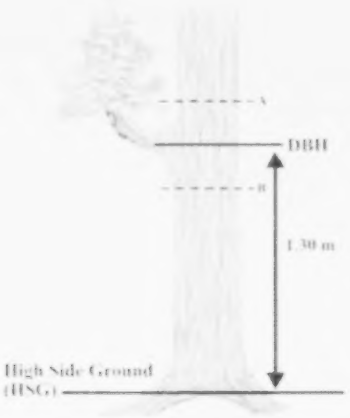
Example 5 **Measuring dbh on curved stems.**



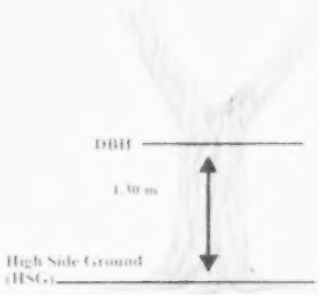
Example 6 **Measuring dbh on elevated root system.**



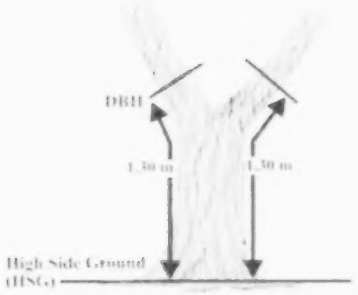
Example 6 **Measuring dbh at swelling at 1.3 m. Measure diameter at "A" above 1.3 m and "B" below 1.3 m and calculate the dbh value for 1.3 m.**



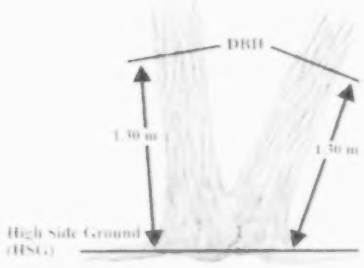
Example 8 **Measuring dbh when branching at 1.3 m. Measure diameter at "A" above 1.3 m and "B" below 1.3 m and calculate the dbh value for 1.3 m.**



Example 9 **Measuring trees forked above dbh.**



Example 10. **Measuring trees forked below dbh.**



Example 5 **Measuring trees forked at the base.**

Appendix K: Calculation of Basal Area

Network
Label: 406

Field Calculation of Basal Area by Species

1234567

[Live, non-residual trees only]

Field Dot Tally

Small tree plot: 3.99m

dbh Range (cm)	Species _F__	**Species _H__**	Species __C_	Species ___	Species ___	Species ___
0.1 – 2.9						
3.0 – 5.9						
6.0 – 8.9						

Large Tree Plot 11.28 m

9.0 – 14.9	//	///// //	1			
15.0 – 19.9	///	////	///			
20.0 – 24.9	//	/////	//			
25.0 – 29.9	///// ///	//				
30.0 – 34.9	////					
35.0 – 39.9	/					
40.0 – 44.9						
45.0 – 49.9						
50.0 – 59.9						
60.0 – 69.9						
70.0 – 79.9						
80.0 – 89.9						
90.0 – 99.9						
100.0 – 109.9						
110.0 – 119.9						
120.0 – 129.9						
130.0 – 139.9						
140.0 – 149.9						
150.0 – 199.9						
Totals	20	18	6			

Table K: Field calculation of basal area per hectare by species for NFI plots only.

This table is adapted from the National Forest Inventory procedures for British Columbia.

Field calculation of basal area per hectare by species

Network Label	1234567

Used for determining leading, second and other species for site tree selection

11.28-m radius*, live trees, no residuals

		Tree Count by Species (Enter Tree Species Below)							Basal Area per Ha by Species (Enter Tree Species Below)					
dbh Range	dbh Class (midpoint)	F	H	C				Weighted Basal Area by Tree	F	H	C			
0.1 – 2.9	2.5							0.09**						
3.0 – 5.9	4.5							0.32**						
6.0 – 8.9cm	6.5							0.88**						
9.0 – 14.9	12.0	2	7	1				0.28	0.56	1.96	0.28			
15.0 – 19.9	17.5	3	4	3				0.60	1.8	2.4	1.8			
20.0 – 24.9	22.5	2	5	2				0.99	1.98	4.95	1.98			
25.0 – 29.9	27.5	8	2					1.48	11.84	2.96				
30.0 – 34.9	32.5	4						2.07	8.28					
35.0 – 39.9	37.5	1						2.76	2.76					
40.0 – 44.9	42.5							3.55						
45.0 – 49.9	47.5							4.43						
50.0 – 59.9	55.0							5.94						
60.0 – 69.9	65.0							8.30						
70.0 – 79.9	75.0							11.04						
80.0 – 89.9	85.0							14.19						
90.0 – 99.9	95.0							17.72						
100.0 – 109.9	105.0							21.65						
110.0 – 119.9	115.0							25.97						
120.0 – 129.9	125.0							30.68						
130.0 – 139.9	135.0							35.78						
140.0 – 149.9	145.0							41.28						
150.0 – 199.9	175.0							60.13						
200.0 – 249.9	225.0							99.40						

** The 0.1- to 8.9-cm classes are measured on the 3.99-m plot thus the proportionately highet BA tree

Tree count totals by species		20	18	6				Basal area total by spp.	27.22	12.27	4.06			
Total Trees	44							All spp. total basal area	43.55	43.55	43.55			
								Percentage	63	28	9			

Instructions: 1) Enter sample number, 2) enter tree species on both the left and right hand columns of the sheet, 3) enter tree count by diameter classes, 4) sum the tree count at the bottom of the sheet to confirm that no trees were missed, 5) multiply the tree count for each species/dbh class combination by the weighted basal area for that dbh class and enter the result in the right hand columns of the spreadsheet, 6) total the basal area for each species, 7) summarize the total basal area for all species and record the number in all of the "All spp. total basal area" columns, 8) record the percentage basal area for each species.

Appendix L: Core Sampling

Core Sample Extraction

Using a 5.5-mm borer, core selected tree at dbh facing plot center, if possible. If dbh cannot be bored conveniently, record the height of boring; corrections will be made later.

- 5-mm borers are used, as thinner cores are too fragile to survive the handling, transport, and processing required.
- Maintain sharp borers to prevent the inevitable twisting, damage, and breakup caused by dull borers.

On small diameter trees out of the main plot that are too small to bore, it may be appropriate to cut the tree down close to the base. Cut a small disc (1–2 cm in thickness) from the tree stem and submit this for age data collection. Label the disc with a tree number (it would be a 9000 series number) or put in a numbered bag with the tree number, species, and sample number.

Core Sample Storage

As the core samples will be lab analyzed by the CFS for several purposes, it is important to protect the cores from damage and rot. The following procedures outline how to ensure this. For photos of core samples and commonly encountered issues from "bad" samples, see sections below.

1. Collect all tree cores in labeled, clear "straws" and return them to the field office. The straws with the cores in them must be stapled (**not taped or folded**) so that moisture can freely exit the straw. Taped cores will cause the sample to rot, impairing an accurate lab analysis.
2. Clearly record at the following information on self-adhesive, waterproof labels (Label 1), and attach to straw:

NFI Tree Core Sample Label	
Network Label : _____	Jurisdiction: _____
Collector: _____	Date: _____
Measurement # : 0 1 2 3 4	Tree # : _____
Genus/Species: _____	Field Age: _____
Tree Height (m):_____	Bore Ht (m): _____
Tree DBH (cm):_____	Bore DOB (cm): _____

Label 1 Example of a Tree Core Sample Label

- **NFI Network Label:** The seven digit NFI plot identifier.
- **Jurisdiction:** Record the appropriate two-letter province/territory code.
- **Collector:** Record the name of the crew member that collected the sample.
- **Date:** Enter the date of the sample collection (yyyy/mm/dd).
- **Measurement #:** Circle the NFI measurement cycle (0 = establishment, 1 = first remeasurement, etc.)
- **Tree #:** The unique number assigned to each sample collected from a given soil pit.
- **Genus/Species:** Identify the genus and species of the tree.
- **Field Age:** Record the field age count.
- **Tree Height:** Record the height of the tree in metres.
- **Bore Ht.**: Record the height at which the tree was cored.
- **Tree dbh:** Record the diameter of the tree at breast height.
- **Bore DOB:** Record the diameter outside bark of the tree at the height it was cored.

3. The samples should be dried as soon as possible in a 70°C oven for at least 24 h. This reduces the moisture content to below 10% and arrests any deterioration by fungi. The cores may be left inside the straws while they are drying in the oven as the straws can tolerate 70° temperatures without melting.

4. If the cores cannot be dried right away, they should be maintained chilled until the end of the field shift, and then dried in a proper oven. Note that refrigeration is preferable to freezing, which can cause core cells to rupture due to the build-up of ice needles on the sample.

Core Sample Transport

1. Bundle the cores from each sample into groups prior to shipment. The cores should be shipped, if practical, at the end of each field shift after they have been dried.

2. With each bundle, a typed spreadsheet should be included with the following information for each core:

- **NFI Network Label:** The seven digit NFI plot identifier.
- **Jurisdiction:** Record the appropriate two-letter province/territory code.
- **Collector:** Record the name of the crew member that collected the sample.
- **Date:** Enter the date of the sample collection (yyyy/mm/dd).

- **Measurement #:** Circle the NFI measurement cycle (0 = establishment, 1 = first remeasurement, etc.).
- **Tree #:** The unique number assigned to each sample collected from a given soil pit.
- **Genus/Species:** Identify the genus and species of the tree.
- **Field Age:** Record the field age count.
- **Tree Height:** Record the height of the tree in metres.
- **Bore Ht.**: Record the height at which the tree was cored.
- **Tree dbh:** Record the diameter of the tree at breast height.
- **Bore DOB:** Record the diameter outside bark of the tree at the height it was cored.
- **Site Tree Type:** (i.e., top height, leading species, second leading species, other major species or extra).
- Comments indicating if the complete core was note included (e.g., central portion is rotten or center of tree could not be reached by the increment borer).

3. Courier samples to the following location:

c/o **Thierry Varem-Sanders**

Natural Resources Canada

Northern Forestry Centre

5320 122 Street

Edmonton, AB T6H 3S5

Phone: (780) 435-7292

Use the following guidelines when filling out sample labels:

Core Sample Photographs and Descriptions

The 11 photographs and accompanying descriptions in this appendix emphasize some of the core sampling methodology errors that can be avoided. Photos courtesy of Thierry Varem-Sanders (2002).

It is permissible to use a soft pencil when counting rings in the field, but do not use a pen (marker) of any kind to mark the core samples. Photo 1 illustrates how ink can bleed a substantial distance into the core, sometimes obscuring the tree rings, and making digital analysis of tree rings nearly impossible.

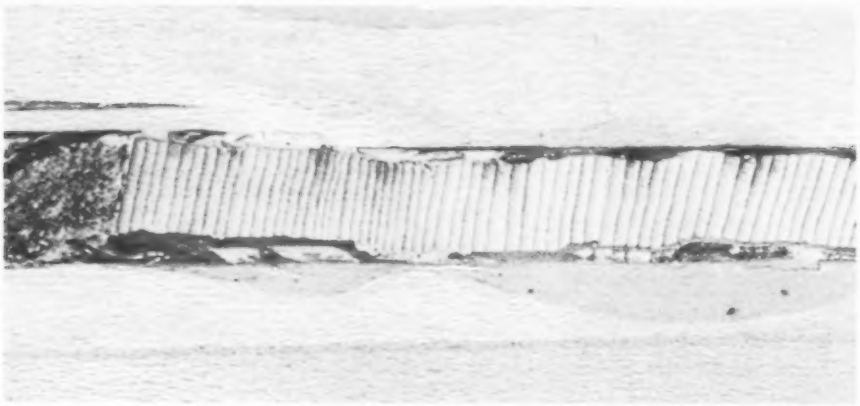


Photo 1 **Pen marks on core sample.**

Photo 2 illustrates a core that shattered in one location due to core rot. The rot itself is not a problem, because it does not mask the ring boundaries. However, the shatter will cause a miscounting of the rings. It is also uncertain as to how many rings may be missing entirely. Re-sample, if possible, when shattered cores due to rot are encountered.

Photo 2 **Core sample with significant rot.**

Photo 3 illustrates a core with a significant branch defect, causing serious warping of the rings. Other defects that are also problematic include fire scars and mechanical bruising. In all cases, the rings become seriously distorted, or some rings can be entirely missing. If possible, the core should be re-sampled.

Photo 3 **Core sample with significant branch defect.**

Photo 4 shows what can happen when the core sampled is extracted using a damaged increment borer. In this case, the corer probably has a chip missing from the tip (this happens if corers are dropped against concrete or rock). The result is that the core shears at regular intervals. A worst case scenario would result in the core being torn into several segments, making the lab analysis impossible. Ensure that increment borers are well maintained and that in the field the tip is not dropped against objects that will damage the borer. If the tip of an increment borer becomes chipped, it **should be discarded**, as no amount of sharpening will fix it.

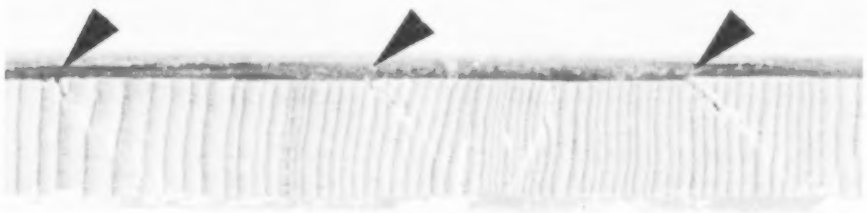


Photo 4 **Core sample extracted using a damaged borer.**

Photo 5 illustrates what happens when the core sample is extracted using a dull increment borer. The dull borer significantly twisted the core sample (note the wavy edges). This issue becomes a great concern in trees with fine rings, as it causes the rings to collapse and makes them functionally "invisible." Increment borers become dull with use and should be sharpened if they do not easily engage the wood and if they will not cut a clean-edged hole when rotated on a sheet of paper.

Another problem with this sample is that the operator had trouble inserting the increment borer into the tree, and wiggled the borer back and forth for the first few turns. This resulted in the shearing marked in Photo 5 and Photo 6.

Photo 5 **Core sample extracted using a dull borer.**

This core sample had the same shearing issues as Photo 5. A shear is clearly visible in the fifth ring.

Photo 6 **Core sample extracted using a dull borer.**

In Photo 7, the increment borer has become so dull that is has caused the core sample to be sheared into several pieces. When the core sample is received in more than three pieces, it is very difficult to determine the original order of the pieces of core sample, making core width measurements impossible. Increment borers become dull with use and should be sharpened if they do not easily engage the wood and if they will not cut a clean-edged hole when rotated on a sheet of paper.

Photo 7 **Core sample extracted using a very dull borer.**

Photos 8 and 9 illustrate a core sample that was stored in a sealed straw with inadequate ventilation, resulting in a moldy sample. To stabilize the core samples, the ends of the straws should be stapled to allow moisture to freely exit the straw. They should also be refrigerated (not frozen) and sent ASAP at the end of each field work shift.

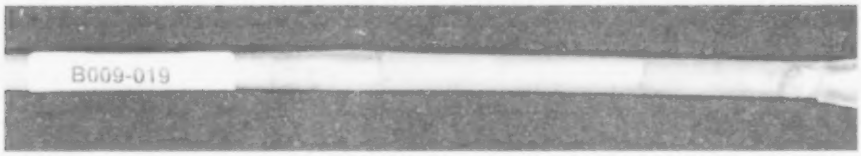


Photo 8 **Straw containing moldy core sample.**

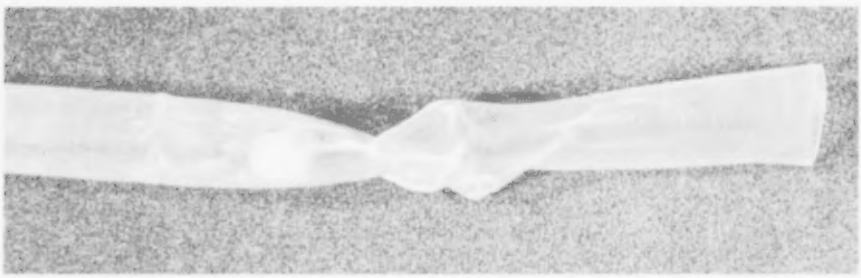


Photo 9 **Moldy core sample removed from the straw.**

It is important that the straws with the core samples be stapled (not taped or folded) so that moisture can freely exit the straw (Photos 10 and 11).

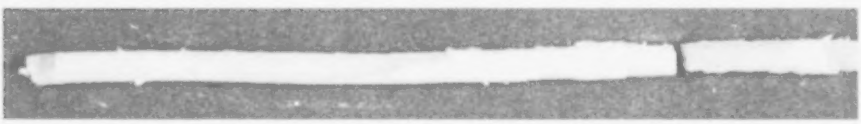


Photo 10 **Improperly stored core sample stored in straw with crimped end.**

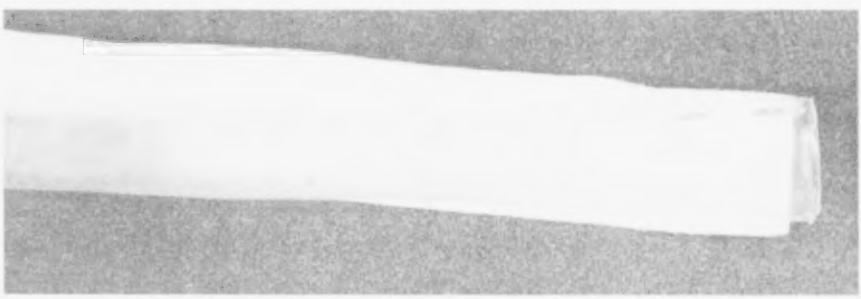


Photo 11 **Properly stored core sample stored in straw with stapled end, allowing for air circulation around sample.**

Appendix M: Soil Sample Processing Lab Analysis Protocol

CANADIAN FORESTRY SERVICE

PACIFIC FORESTRY CENTRE

CHEMICAL SERVICES LAB PROCEDURES

NATIONAL FOREST INVENTORY (NFI)

FOREST FLOOR, MINERAL SOIL, AND DEEP ORGANIC SOIL ANALYSIS

JULY 2007

GENERAL

1. Samples are received from field sites at Pacific Forestry Centre - Shipping and Receiving approximately every 10 days. Samples arriving after 4 p.m. are placed in a Cold Room (4°C) for entry and handling on the following day. In the case of Friday arrival after 4 p.m., samples are handled the following Monday.
2. Samples are brought to the Analytical Chemistry Lab and separated into mineral, deep organic, or forest floor type as designated by the sampling contractor.
3. Site Information is transcribed from the individual samples to a Data sheet ID KEY. Missing information or samples are noted. Information from the Tally cards from each site supplements identification in the entering of samples for lab analysis. Date of receipt in the lab is noted. Laboratory numbers are assigned to each sample and noted on the Data sheet ID KEY. Inner tags are denoted with the assigned lab # and saved for reference information.

FOREST FLOOR

1. Samples submitted as forest floor are placed in the drying oven @ 70°C for 24–72 h and taken to constant weight dryness. If the forest floor material is contained in plastic bags, it must be transferred to paper bags for drying with care taken to include all mass. Determination of constant dryness degree is at the discretion of lab staff. In very wet sites, this may take as long as 5–7 days. Total mass of the dry sample is recorded.
2. Sample is separated into the following components:
   - cobbles and stones

- live roots
- > 8 mm non forest floor
- < 8 mm.

3. The sample is broken apart by hand. All cobbles and stones are removed and saved and the mass recorded.
4. Ideally, forest floor samples arriving in the lab for analysis should not contain any woody debris, shrub, herb, mosses, or live plant material. If any of these, and decayed wood and decayed roots that have not become part of the forest floor, are present, they must be removed and set aside for inclusion with > 8-mm fraction (in 7. below). As well, no mineral material should be sampled as part of the forest floor layer but if this has occurred and such material has been submitted, the dried mineral material from the interface will be included in the < 8-mm fraction.
5. Live roots are separated from the forest floor sample and weighed. Mass is recorded
6. The sample is sieved through an 8-mm mesh.
7. Material held back by 8 mm (> 8 mm) is added to non-forest floor material (in 4. above) and the total mass is recorded. This material is discarded.
8. The forest floor material (< 8 mm) is weighed and mass recorded.
9. The < 8-mm sample fraction is homogenized and a representative portion is selected and is stored in a labeled 750-mL food container.
10. Approximately 60-mL subsample from the 750-mL container is ground in a Wiley Mill to pass 1 mm and saved in a 30-dram (60-mL) snap top vial.
11. Total carbon, total nitrogen, and total sulfur are determined on 1 mm material by the LECO CNS 2000 Elemental Analyzer and the values recorded.
12. NOTE: Before total carbon, nitrogen, and sulfur analysis, the 1-mm sample must be re-dried @ 70°C for 24 h.
13. Following laboratory analysis, samples contained in the 750-mL food container and in the 30-dram (60-mL) snap cap vial are stored in a cool dry environment for future analysis of additional chemical parameters.

MINERAL SOIL FRACTION

1. Samples submitted and recorded as mineral soils are removed from their paper bags and placed to air-dry on brown paper sheets on trolleys with care taken to transfer total mass. Samples are dried for 5–15 days at room temperature (25°C) and taken to "constant air dryness" at the discretion of the lab staff. Normally this will be 7 days.
2. At air-dried condition, the sample total mass is determined and recorded.
3. The total air-dried sample is sieved into the following components to pass:

- < 2 mm
- 2–75 mm (gravel) NOTE: An 8-mm sieve is used in the separation process.

- > 75 mm (cobbles).

4. Organic matter (roots mass). The larger material is picked from the mineral sample by hand and then by tweezers from the material remaining on the 2-mm sieve and is saved for moisture determination.

5. All 4 component masses (in 3. above) are recorded individually.

6. If the organic material accounts for > 1% of the total mass, moisture content determination (at 70°C) is completed and recorded. Organic material is discarded.

7. The > 2-mm fraction is discarded.

   - A representative portion of the < 2-mm fraction is saved to fill a 750-mL plastic food container.

   - A 50-g subsample of the < 2-mm fraction is taken for moisture content determination (at 105°C). The value is determined and recorded.

   - A 50–100 g subsample of the < 2-mm fraction is taken for particle size analysis and determination of textural class.

8. A 10-g subsample of the < 2-mm fraction is taken for pH determination. If the result is pH > 6.7, analysis for organic carbon is carried out on the LECO CR12 Analyzer.

9. The sample remaining is archived and stored in a cool dry environment for future analysis of additional chemical parameters.

10. A subsample of < 2 mm fraction is ground to 100 mesh in the Siebtechnic Mill and saved in a 30-dram (60 mL) snap cap vial for additional analysis.

11. Total carbon, total nitrogen, and total sulfur are determined on the 100-mesh ground sample by the LECO CNS 2000 Elemental Analyzer and the values recorded.

12. Following laboratory analysis, samples contained in the 30-dram (60-mL) snap cap vial are stored with the archival samples.

DEEP ORGANIC

1. Samples submitted as deep organic are placed in the drying oven @ 70°C for 24–72 h, and taken to constant weight dryness. If the material is contained in plastic bags, it must be transferred to paper bags for drying with care taken to include all mass. Determination of constant dryness degree is discretional on the part of lab staff. In very wet sites, this may be as long as 5–7 days. Total mass of the dry sample is recorded.

2. Sample is separated into the following components:

   - cobbles and stones

   - live roots

   - > 8 mm decomposed roots, foliage, forest floor, etc.

   - < 8 mm (sieved).

3. The sample is broken apart by hand. All of the fractions are saved and the masses are recorded.

4. The < 8-mm sample fraction is homogenized and a representative portion is selected and is stored in a labeled 750-mL food container.

5. Approximately 60-mL subsample from the 750-mL container is ground in a Wiley Mill to pass 1mm and saved in a 30-dram (60-mL) snap top vial.

6. Total carbon, total nitrogen, and total sulfur are determined on 1-mm material by the LECO CNS 2000 Elemental Analyzer and the values recorded.

   - NOTE: Before total carbon, nitrogen, and sulfur analysis, the 1-mm sample must be re-dried @ 70°C for 24 h.

7. Following laboratory analysis, samples contained in the 750-mL food container and in the 30-dram (60-mL) snap cap vial should be stored in a cool dry environment for future analysis of additional chemical parameters.

Appendix N: Photos of Field Sampling Tools used in Forest Floor and Soil Sample Excavation

The photographs and accompanying descriptions in this appendix illustrate some of the equipment that is used to extract forest floor organic samples and bulk density soil samples for lab analysis.

Photo 1 **From left to right: hand clippers (for clipping fine roots and shrubs, herbs and grasses at the microplot); hand trowel; folding aluminum hand saw (for cutting forest floor organic sample); ruler and long-handled, stainless steel soup spoon (for scooping finely textured soil at successive depths).**

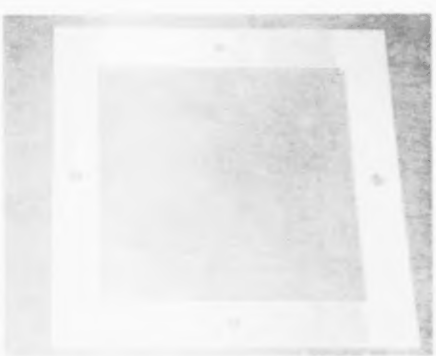


Photo 2 **20 × 20 cm (inside dimensions) template for cutting a sample of forest floor organics for lab analysis.**

Photo 3 **3-mm glass beads used in the field for volume measurement of excavated soil samples.**

Appendix O: NFI Soil Sample and Shipping Labels

NFI SAMPLE LABEL - FOREST FLOOR AND SOILS	
Network Label _____	Jurisdiction _____
Crew Name _____	Date _____
Measurement # 0 1 2 3 4	Sample number _____
Pit number (circle one) MP1 MP2 MP3 MP4 LP0	
Sample Type (check one)	
☐ Forest Floor ☐ Mineral Soil ☐ Deep Organic Soil	
Upper and Bottom Depth (check one)	
☐ Layer 1 Upper (cm) 0 Bottom (cm) 15	
☐ Layer 2 Upper (cm) 15 Bottom (cm) 35	
☐ Layer 3 Upper (cm) 35 Bottom (cm) 55	
☐ Layer 4 Upper (cm) 55 Bottom (cm) 75	
☐ OTHER Upper (cm) ____ Bottom (cm) ____	
Template Dimensions (if applicable)	Volume (mL/cm^3)
Length _____ Width _____ (cm)	_____ mL

Label 1 **Sample soil label.**

Use the following guidelines when filling out sample labels:

1. **NFI Network Label or Plot Number:** The seven digit NFI plot identifier.
2. **Jurisdiction:** Record the appropriate two-letter province/territory code.
3. **Crew Name:** Record the name of the crew member that collected the sample.
4. **Date:** Enter the date of the sample collection (yyyy/mm/dd).
5. **Measurement #:** Circle the NFI measurement cycle (0 = establishment, 1 = first remeasurement, etc.)
6. **Sample Number:** The unique number assigned to each sample collected from a given soil pit.
7. **Pit Number:** Circle the pit code that indicates where the sample was collected.

   MP1 to MP4 = Microplot 1 to Microplot 4; **LP0** = Large soil pit
8. **Sample Type:** Check the type of sample collected.
9. **Upper and Bottom Depth (cm):** Indicate sample upper and bottom depth by checking one of the boxes. If sample upper and bottom do not exactly match one of the standard NFI depth increments (e.g., forest floor samples), check "Other" and record the sample upper and bottom depth.
10. **Template Dimensions (cm):** If applicable, record the length and width of the sampling template used to collect the sample.
11. **Volume:** Record the volume of the sample collected to the nearest 10 mL.

NFI Sample Shipping Label

Each shipping form must include:

1. Name of sender
2. Signature of sender
3. Company and method used to ship sample
4. Tracking number
5. Jurisdiction
6. Total number of sample bags shipped
7. A table including the following information for **each** of the shipped samples (Example 18):
    a. **Network label code:** Seven digit code
    b. **Sample date:** Date the sample was collected
    c. **Crew initials:** The initials of the crew that collected the sample
    d. **Sample type:** The type of sample (forest floor organic, mineral soil, organic soil)
    e. **Pit #:** The number of the pit from which the sample was collected.
    f. **Sample #:** The unique number assigned to each sample collected from a given pit.
    g. **Bags/Sample:** The number of bags per sample

Name of Sender: Jane Smith
Signature of Sender: Jane Smith
Shipped via: Great Canadian Shipping Co., regular post
Tracking number: 112YR003
Jurisdiction: BC
Total Number of Sample Bags Shipped: 15

NETWORK LABEL	DATE SAMPLED	CREW	SAMPLE TYPE	PIT #	SAMPLE #	BAGS/SAMPLE
1234567	2007-May-30	GH/JV	Organic	MP1	1	1
1234567	2007-May-30	GH/JV	Organic	MP1	2	1
1234567	2007-May-30	GH/JV	Organic	MP1	3	1
1234567	2007-May-30	GH/JV	Organic	MP1	4	1
1122334	2007-Jun-01	GH/BB	Forest Floor	MP1	1	1
1122334	2007-Jun-01	GH/BB	Mineral	MP1	2	1
1122334	2007-Jun-01	GH/BB	Mineral	MP1	3	1
1122334	2007-Jun-01	GH/BB	Mineral	MP1	4	1
1122334	2007-Jun-01	GH/BB	Forest Floor	MP2	1	1
1122334	2007-Jun-01	GH/BB	Mineral	MP2	2	1
1122334	2007-Jun-01	GH/BB	Mineral	MP2	3	1
1122334	2007-Jun-01	GH/BB	Forest Floor	MP3	1	1
1122334	2007-Jun-01	GH/BB	Mineral	MP3	2	1
1122334	2007-Jun-01	GH/BB	Forest Floor	MP4	1	1
1122334	2007-Jun-01	GH/BB	Mineral	MP4	2	1

Label 2 **Example of a completed shipping form**

Appendix P: NFI Land Cover Classification Scheme

The following was adopted from the BC Land Cover Classification Scheme (1999).

Classifying Land Cover

The Land Cover Classification Scheme is based on current cover. Cover may be vegetated or non-vegetated. Vegetated cover is either treed or non-treed; non-vegetated cover is either land or water. In most cases, uniform areas (polygons) are delineated on mid-scale aerial photographs (1:10 000 to 1:20 000). Each polygon is then assessed using hierarchical classes, first into Vegetated or Non-Vegetated, then by cover type, landscape position, and so on, to the lowest level identifiable.

Figure 1 illustrates the Land Cover Classification process. Figure 2 illustrates the structure of the land cover classification scheme.

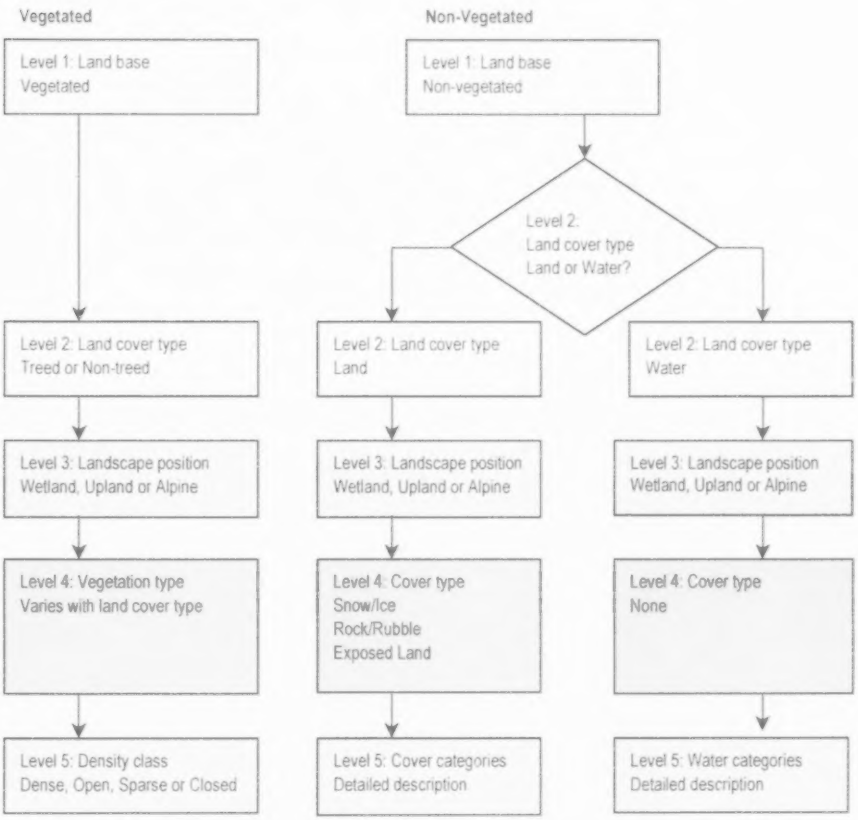


Figure 1 The Land Cover Classification Scheme process map.

Polygon Attribute - The Information Source for the Cover Designation

Application of the Land Cover Classification Scheme provides a land cover designation based on the categories described below. The cover for each polygon is derived from polygon attributes estimated by photo interpretation and calibrated based on air and ground surveys.

The land cover designation gives a categorization of the polygon based on the Land Cover Classification Scheme. Lower layer (such as shrubs, herbs, and bryoids) vegetation information is not provided when a higher layer (such as trees) exists.

The Coding System

The land classification of each polygon is summarized as a seven-letter code to facilitate broad land classification reporting. The classification scheme also includes the criteria for distinguishing cover types within the polygon. These criteria are critical for assessing specific tree, shrub, herbaceous, bryoid, and non-vegetated communities within polygon boundaries (referred to as land cover components). Code letters are given in the detailed descriptions that follow.

The following is an example of the derivation of the seven-letter Land Cover Class Code:

Level	Estimated attributes	Code assigned
1	Vegetated crown closure ≥ 5%	**V** (Vegetated)
2	Tree crown closure ≥ 10%	**T** (Treed)
3	Not Alpine or Wetland	**U** (Upland)
4	Coniferous ≥ 75% of total Crown Closure	**TC** (Coniferous)
5	Tree crown closure = 80%	**DE** (Dense)

The Land Cover Class code for this polygon would be **VTUTCDE**.

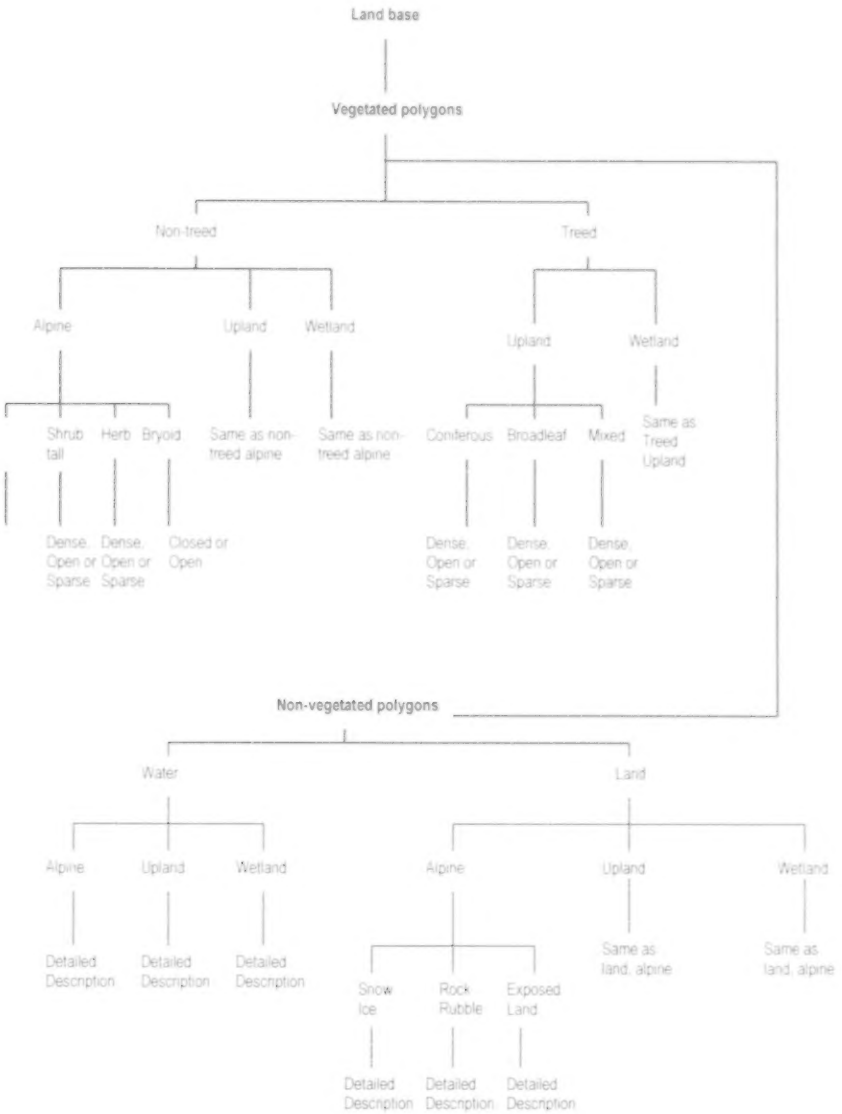


Figure 2 **Structure of the Land Cover Classification Scheme**

Level 1 - Classifying the Land Base

The first level of the classification scheme classifies the presence or absence of vegetation, as Vegetated or Non-Vegetated.

V = Vegetated
A polygon is considered Vegetated when the total cover of trees, shrubs, herbs, and bryoids (other than crustose lichens) covers ≥ 5% of the total surface area of the polygon.

N = Non-Vegetated
A polygon is considered Non-Vegetated when the total cover of trees, shrubs, herbs, and bryoids covers < 5% of the total surface area of the polygon. Bodies of water are classified as Non-Vegetated.

Classifying Vegetated Polygons

If the polygon is classed as Vegetated, the following levels apply. (If classified as Non-Vegetated, see Classifying Non-Vegetated Polygons for a description of further levels.)

Level 2 - Land Cover Type

The first determination for Vegetated polygons is whether they are Treed or Non-Treed.

T = Treed
A polygon is considered Treed if ≥ 10% of the polygon area, by crown cover, consists of tree species of any size. See Appendix E of the NFI Design Document for a list of tree species.

N = Non-Treed

A polygon is considered Non-Treed if > 10%, by crown cover, of the polygon area consists of tree species of any size.

Level 3 - Landscape Position

Once the polygon has been classified as Treed or Non-Treed, the location relative to elevation and drainage is determined.

W = Wetland
Wetland has numerous definitions in the literature. The definition used for the classification is taken from Fraser et al. (1995):

Wetland is land having the water table at, near, or above the soil surface, or which is saturated for a long enough period of time to promote wetland or aquatic processes. These wetland processes are indicated by the presence of Organic or Gleysolic soils and hydrophytic vegetation. See wetland definitions in Section 10.5 for a more complete description complete description.

U = Upland
A broad class that includes all non-wetland ecosystems that range from very xeric to hygric soil moisture regimes.

A = Alpine
A polygon is considered Alpine when it is treeless (for practical purposes, < 1% tree cover can be included within the Alpine category), with alpine vegetation dominated by shrubs, herbs, graminoids, bryoids, and lichens. Rock, ice, and snow dominate much of the Alpine. Alpine does not typically include the parkland and krummholz forest types. Alpine is a classification level of Non-Treed areas above the tree line only.

Level 4 - Vegetation Type

Once the polygon is classed as Treed or Non-Treed and determined to be Wetland or Upland, it is further classified by the type of vegetation within the unit:

Vegetated Treed

Treed units can be Coniferous, Broadleaf, or Mixed.

TC = Coniferous
Defined as those trees classified botanically as Coniferae; cone-bearing trees having needles or scale-like leaves, usually evergreen. These species are commonly referred to as conifer or softwoods. See Appendix E of the NFI Design Document for a list of species and species codes.

The polygon is classified as Coniferous when trees cover a minimum of 10% of the total polygon area by crown cover, and coniferous trees are ≥ 75% of the total tree basal area.

TB = Broadleaf
Defined as those trees classified botanically as Angiospermae in the subclass Dicotyledoneae. These species are commonly referred to as deciduous or hardwoods. See Appendix E of the NFI Design Document for a list of species and species codes.

The polygon is classified as Broadleaf when trees cover a minimum of 10% of the total polygon area by crown cover, and broadleaf trees are ≥ 75% of the total tree basal area.

TM = Mixed
The polygon is classified as Mixed when trees cover a minimum of 10% of the total polygon area by crown cover, but neither coniferous nor broadleaf trees account for ≥ 75% of the total tree basal area.

Vegetated Non-Treed Units

Non-Treed units can be Shrub, Herb, or Bryoid.

Shrub

Shrubs are woody perennial plants, both evergreen and deciduous, that have a relatively low growth habit, and are generally multi-stemmed, rather than having one bole. They differ from a tree by their low stature (< 10 m) and non-treelike form. A reporting break is made between Tall (≥ 2 m) and Low (< 2 m) for wildlife management interpretation

purposes. Other breaks may be used if preferred, as height data are estimated as a continuous variable.

For a polygon to be classed as Shrub, it must have a minimum of 10% ground cover of shrubs, or shrubs must constitute more than 1/3 of the total vegetation cover.

ST = Shrub Tall
A Shrub polygon with average height ≥ 2 m.

SL = Shrub Low
A Shrub polygon with average shrub height < 2 m.

Herb

Herbs are defined, for this system, as vascular plants without a woody stem, including ferns, fern allies, grasses, and grass-like plants.

If a polygon does not meet the definition of Shrub, then it can be classed as Herb if it has a minimum of 20% ground cover of herbs, or herbs constitute more than 1/3 of the total vegetation cover.

The Herb class has two further subdivisions based on the proportion of forbs and graminoid plants. The subclasses Forbs and Graminoids are used when any one group accounts for > 50% of the herb cover.

Graminoids are herbaceous plants with long, narrow leaves characterized by linear venation; including grasses, sedges, rushes, and other related species.

Forbs are herbaceous plants other than graminoids, including ferns, club mosses, and horsetails.

HE = Herb
An Herb polygon with no distinction between forbs and graminoids.

HF = Herb – Forbs
An Herb polygon with forbs > 50% of the herb cover.

HG = Herb – Graminoids
An Herb polygon with graminoids > 50% of the herb cover.

Bryoid

Bryoids are bryophytes (mosses, liverworts, and hornworts) and lichens (foliose or fruticose; not crustose).

If a polygon does not meet the definition of Shrub or Herb, then it can be classed as Bryoid if it has > 50% of the vegetation cover in bryoids, and herb and shrub cover must each constitute < 20%.

The Bryoid class has two further subdivisions based on the proportion of bryophytes and lichens. The class is subdivided into Bryophyte or Lichen when any one group accounts for > 50% of the bryoid cover.

BY = Bryoids
A Bryoid polygon with no distinction between mosses and lichens by cover.

BM = Bryoid – Moss
A Bryoid polygon with mosses, liverworts, and hornworts > 50% of the bryoid cover.

BL = Bryoid – Lichens
A Bryoid polygon with lichens (foliose or fruticose; not crustose) > 50% of the bryoid cover.

Level 5 - Density Class

Once a Vegetated polygon is classed up to Level 4, density is reported using the following density classes available by vegetation type. Note that these are reporting breaks only; interpreters can estimate density in a continuous manner (from 0 to 100%).

The density classes for Treed, Shrub, or Herb polygons are as follows:

DE = Dense
Tree, shrub, or herb cover is between 61% and 100% crown closure for the polygon.

OP = Open
Tree, shrub, or herb cover is between 26% and 60% crown closure for the polygon.

SP = Sparse
Tree cover is between 10 and 25% crown closure for treed polygons or cover is between 20 and 25% for shrub or herb cover polygons.

The density classes for Bryoid polygons are as follows:

CL = Closed
Cover of bryoids is > 50% of the polygon.

OP = Open
Cover of bryoids is ≤ 50% of the polygon.

Classifying Non-Vegetated Polygons

A polygon is considered Non-Vegetated when the total cover of trees, shrubs, herbs, and bryoids covers < 5% of the total surface area of the polygon.

Level 2 - Land Cover Type

The first decision is whether a polygon is considered to be Land or a Water body. The cover type occupying 50% of the polygon area is the cover type assigned.

L = Land
The portion of the landscape not covered by water (as defined below), based on the percentage cover area.

W = Water
A naturally occurring, static body of water, > 2 m deep in some portion, or a watercourse formed when water flows between continuous, definable banks.

These flows may be intermittent or perennial; but do not include ephemeral flows where a channel with no definable banks is present. Islands within streams that have definable banks are not part of the stream; gravel bars are part of the stream. Interpretation is based on the percentage area covered.

Classifying Non-Vegetated Land Polygons

If the polygon is classed as Land, the following steps and levels apply. *(If classed as **Water**, see Land Cover Type - Water for a description of further levels.)*

Level 3 - Landscape Position (Land)

This level describes the location of the polygon relative to drainage, and is described as Wetland or Upland.

W = Wetland
Land having a water table near, at, or above the soil surface, or which is saturated for a long enough period to promote wetland or aquatic processes. These wetland processes are indicated by the presence of Organic or Gleysolic soils and hydrophytic vegetation. See wetland definitions later in this appendix for a more complete description.

U = Upland
A broad class that includes all non-wetland ecosystems that range from very xeric to hygric soil moisture regimes.

A = Alpine
A polygon is considered Alpine when it is treeless (for practical purposes, < 1% tree cover can be included within the Alpine category), with alpine vegetation dominated by shrubs, herbs, graminoids, bryoids, and lichens. Rock, ice, and snow dominate much of the Alpine. Alpine does not typically include the parkland and krummholz forest types. Alpine is a classification level of Non-Treed areas above the tree line only.

Level 4 - Non-Vegetated Cover Type (Land)

Once the polygon is classed as Non-Vegetated and determined whether it is Wetland, Upland, or Alpine, it is further classified by the type of non-vegetated condition within the unit. Non-Vegetated polygons are divided into three groups: Snow/Ice, Rock/Rubble, and Exposed Land.

SI = Snow/Ice
Defined as either glacier or snow cover.

RO = Rock/Rubble
Defined as bedrock or fragmented rock broken away from bedrock surfaces and moved into its present position by gravity or ice. Extensive deposits are found in and adjacent to alpine areas and are associated with steep rock walls and exposed ridges; canyons and cliff areas also contain these deposits.

EL = Exposed Land
Contains all other forms of Exposed Land identified by a range of subclasses.

Level 5 - Non-Vegetated Categories (Land)

The dominant material or feature of the non-vegetated area defines classes.

Snow/Ice has two subclasses - **Glacier** and **Snow Cover**:

GL = Glacier
A mass of perennial snow and ice with definite lateral limits, typically flowing in a particular direction.

SC = Snow Cover
Snow or ice that is not part of a glacier, but is found during summer months on the landscape.

Rock/Rubble has four subclasses:

BR = Bedrock
Unfragmented, consolidated rock contiguous with the underlying material.

RT = Rubble, Talus, Blockfield
Fragmented rock, broken away from bedrock surfaces and moved into its present position by gravity or ice.

MS = Rubbly Mine Spoils
Discarded overburden or waste rock moved to extract ore during a mining operation.

LB = Lava Bed
An area where molten rock has flowed from a volcano or fissure and cooled and solidified to form rock.

Exposed Land has 16 subclasses:

RS = River Sediments
Silt, gravel, and sand bars associated with former river channels and present river edges.

ES = Exposed Soil
Any exposed soil not covered by the other categories, such as areas of recent disturbance including mud slides, debris torrents, avalanches, or disturbances such as pipeline rights-of-way or cultivated fields, where vegetation cover is < 5%.

LS = Pond or Lake Sediments
Exposed sediments related to dried-up lakes or ponds.

RM = Reservoir Margin
Land exposed by a drained or fluctuating reservoir. It is found above "normal" water levels and may consist of a range of substrates including gravel, cobbles, fine sediments, or bedrock.

BE = Beach
An area with sorted sediments reworked in recent time by wave action. It may be formed at the edge of fresh or saltwater bodies.

LL = Landing
A compacted area adjacent to a road used for sorting and loading logs.

BU = Burned Area
Land showing evidence of recent burning, either natural or prescribed. Vegetation of < 5% crown cover is present at the time of polygon description.

RP = Road Surface
An area cleared and compacted for the purpose of transporting goods and services by vehicles. Older roads that are used infrequently or not at all may cease to be classified as non-vegetated.

MU = Mudflat Sediment
Flat plain-like areas associated with lakes, ponds, rivers, or streams, dominated by fine-textured sediments. They can be associated with freshwater or estuarine sources.

CB = Cutbank
Part of a road corridor created upslope of the road surface by excavation into the hillside. "Natural" forces may also create Cutbanks.

MO = Moraine
An area of debris transported and deposited by a glacier.

GP = Gravel or Borrow Pit
An area exposed through the removal of sand and gravel.

TS = Tailings
An area containing the solid waste material produced by the mining and milling of ore.

RR = Railway Surface
A roadbed with fixed rails, may contain single or multiple rail lines.

BP = Buildings and Parking
Buildings and associated developments such as roads and parking areas.

AP = Airport
A permanently paved or gravelled area, and associated buildings and parking, used by airplanes.

PM = Open Pit Mine
An exposed area used to extract ore during a mining operation. This may contain associated buildings and any tailing produced by the mining and milling process.

OT = Other
A Non-Vegetated polygon where none of the other exposed land categories can be reliably chosen.

Classifying Non-Vegetated Water Polygons

If the polygon is classed as Water, the following categories apply:

Level 3 - Landscape Position (Water)

The landscape position relative to drainage is determined.

W = Wetland
Land having a water table near, at, or above the soil surface, or which is saturated for a long enough period to promote wetland or aquatic processes. These wetland processes are indicated by the presence of Organic or Gleysolic soils and hydrophytic vegetation. See wetland definitions in Section 10.5 for a more complete description.

U = Upland
A broad class that includes all non-wetland ecosystems that range from very xeric to hygric soil moisture regimes.

A = Alpine
A polygon is considered Alpine when it is treeless (for practical purposes, < 1% tree cover can be included within the Alpine category), with alpine vegetation dominated by shrubs, herbs, graminoids, bryoids, and lichens. Rock, ice, and snow dominate much of the Alpine. Alpine does not typically include the parkland and krummholz forest types. Alpine is a classification level of Non-Treed areas above the tree line only.

Level 4 - Water

WA = Water

A naturally occurring, static body of water, > 2 m deep in some portion, or a watercourse formed when water flows between continuous, definable banks. These flows may be intermittent or perennial; but do not include ephemeral flows where a channel with no definable banks is present. Islands within streams that have definable banks are not part of the stream; gravel bars are part of the stream. Interpretation is based on the percentage area covered.

Level 5 - Water Categories

Four categories have been identified: Lake, Reservoir, River/Stream, and Salt Water.

LA = Lake
A naturally occurring static body of water > 2 m deep in some portion. The boundary for the lake is the natural high water mark.

RE = Reservoir
An artificial basin affected by impoundment of water behind a human-fabricated structure such as a dam, berm, dyke, or wall.

RI = River/Stream
A watercourse formed when water flows between continuous, definable banks. Flow may be intermittent or perennial, but does not include ephemeral flow where a channel with no definable banks is present. Gravel bars are part of a stream, while islands within a stream that have definable banks are not.

SW = Salt Water
A naturally occurring body of water containing salt or generally considered to be salty.

Definitions

The following terms are defined for use in the Land Cover Classification Scheme.

Vegetated Land Definitions

Alpine: Treeless (for practical purposes, < 1% tree cover can be included within the Alpine category), with alpine vegetation dominated by shrubs, herbs, graminoids, bryoids, and lichens. Rock, ice, and snow dominate much of the Alpine. Alpine does not typically include the parkland and krummholz forest types. Alpine is, by definition, treeless; therefore, there is no further classification level of Treed/Non-Treed under this category.

Broadleaf: Trees classified botanically as Angiospermae in the subclass Dicotyledoneae (Bones 1993). These species are referred to as hardwoods. These species are commonly referred to as deciduous or hardwoods.

Bryoids: Bryophytes (mosses, liverworts, and hornworts) and lichens (foliose or fruticose; not crustose).

Coniferous: Trees classified botanically as Coniferae; cone-bearing trees having needles or scale-like leaves, usually evergreen. These species are commonly referred to as conifer or softwoods.

Forbs: Herbaceous plants other than graminoids, including ferns, club mosses, and horsetails.

Graminoids: Herbaceous plants with long, narrow leaves characterized by linear venation; including grasses, sedges, rushes, and other related species.

Herbs: Vascular plants without a woody stem, including ferns, fern allies, grasses, and grass-like plants.

Krummholz: Scrubby, stunted growth form of trees, often forming a characteristic zone at the limit of tree growth at high elevations.

Non-Treed: A polygon is considered Non-Treed if < 10%, by crown cover, of the polygon area consists of tree species of any size.

Parkland: Landscape characterized by strong clumping of trees due to environmental factors.

Shrubs: Woody perennial plants, both evergreen and deciduous, that have a relatively low growth habit, and are generally multi-stemmed, rather than having one bole. It differs from a tree by its low stature (generally < 10 m) and non-treelike form. A reporting break is made between Tall (≥ 2 m) and Low (< 2 m) for wildlife management interpretation. Other breaks may be used if preferred, as height data are estimated as a continuous variable.

Treed: A polygon is considered Treed if ≥ 10% of the polygon area, by crown cover, consists of tree species of any size.

Upland: A broad class that includes all non-wetland ecosystems that range from very xeric to hygric soil moisture regimes.

Vegetated: A polygon is considered Vegetated when the total cover of trees, shrubs, herbs, and bryoids (other than crustose lichens) covers ≥ 5% of the total surface area of the polygon.

Wetland: Land having the water table at, near, or above the soil surface, or which is saturated for a long enough period to promote wetland or aquatic processes. These wetland processes are indicated by the presence of Organic or Gleysolic soils and hydrophytic vegetation. See Wetland definitions later in this section for a more complete description.

Non-Vegetated Land Definitions

Beach (Exposed Land): An area with sorted sediments reworked in recent time by wave action. It may be formed at the edge of fresh or saltwater bodies.

Bedrock (Rock/Rubble): Unfragmented, consolidated rock contiguous with the underlying material.

Buildings and Parking (Exposed Land): Buildings and associated developments such as roads and parking areas.

Burned Area (Exposed Land): Land showing evidence of recent burning, either natural or prescribed. Vegetation of < 5% crown cover is present at the time of polygon description.

Cutbank (Exposed Land): Part of a road corridor created upslope of the road surface by excavation into the hillside. "natural" processes may also create Cutbanks.

Exposed Land: Contains all other forms of exposed land identified by a range of 16 subclasses: Beach; Buildings and Parking; Burned Area; Cutbank; Exposed Soil; Gravel Pit; Landing; Moraine; Mudflat Sediment; Other; Pond or Lake Sediments; Railway Surface; Reservoir Margin; River Sediments; Road Surface; Tailings.

Exposed Soil (Exposed Land): Any exposed soil not covered by the other categories (e.g., areas of recent disturbance including mud slides, debris torrents, avalanches, or disturbances such as pipeline rights-of-way or cultivated fields) where vegetation cover is < 5%.

Glacier (Snow/Ice): A mass of perennial snow and ice with definite lateral limits, typically flowing in a particular direction.

Gravel Pit (Exposed Land): An area exposed through removal of sand and gravel.

Lake: A naturally occurring static body of water > 2 m deep in some portion. The boundary for the lake is the natural high water mark.

Land: The portion of the landscape not covered by water (as defined below) based on the percentage area cover.

Landing (Exposed Land): A compacted area adjacent to a road used for sorting and loading logs.

Lava Bed: An area where molten rock has flowed from a volcano or fissure and cooled and solidified to form rock.

Moraine (Exposed Land): An area of debris transported and deposited by a glacier.

Mudflat Sediment (Exposed Land): Flat plain-like areas associated with lakes, ponds, rivers, or streams, dominated by fine-textured sediments. They can be associated with freshwater or estuarine sources.

Non-Vegetated: A polygon is considered Non-Vegetated when the total cover of trees, shrubs, herbs, and bryoids covers < 5% of the total surface area of the polygon. Bodies of water are to be classified as Non-Vegetated.

Other (Exposed Land): A Non-Vegetated polygon where none of the other exposed land categories can be reliably chosen.

Pond or Lake Sediments (Exposed Land): Exposed sediments related to dried-up lakes or ponds.

Railway Surface (Exposed Land): A roadbed with fixed rails; may contain single or multiple rail lines.

Reservoir: An artificial basin affected by impoundment of water behind a human fabricated structure such as a dam, berm, dyke, or wall.

Reservoir Margin (Exposed Land): Land exposed by a drained or fluctuating reservoir. It is found above "normal" water levels, and may consist of a range of substrates including gravel, cobbles, fine sediments, or bedrock.

River/Stream: A watercourse formed when water flows between continuous, definable banks. Flow may be intermittent or perennial, but does not include ephemeral flow where a channel with no definable banks is present. Gravel bars are part of a stream, while islands within a stream that have definable banks are not.

River Sediments (Exposed Land): Silt, gravel, and sand bars associated with former river channels and present river edges.

Road Surface (Exposed Land): An area cleared and compacted for the purpose of transporting goods and services by vehicles. Older roads that are used infrequently or not at all may cease to be classified as non-vegetated.

Rock/Rubble: Bedrock or fragmented rock broken away from the bedrock surface and moved into its present position by gravity or ice. Extensive deposits are found in and adjacent to alpine areas and are associated with steep rock walls and exposed ridges. Canyons and cliff areas also contain these deposits.

Rubble, Talus, Blockfield (Rock/Rubble): Fragmented rock, broken away from the bedrock surface, and moved into its present position by gravity or ice.

Rubbly Mine Spoils (Rock/Rubble): Discarded overburden or waste rock moved to extract ore during a mining operation.

Salt Water: A naturally occurring body of water containing salt or generally considered to be salty.

Snow Cover (Snow/Ice): Snow or ice that is not part of a glacier, but is found during summer months on the landscape.

Tailings (Exposed Land): An area containing the solid waste material produced by the mining and milling of ore.

Water: A naturally occurring, static body of water, ≥ 2 m deep in some portion, or a watercourse formed when water flows between continuous, definable banks. These flows may be intermittent or perennial; but do not include ephemeral flows where a channel with no definable banks is present. Islands within a stream with

definable banks are not part of the stream; gravel bars are part of the stream. Interpretation is based on the percentage area covered.